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342.1 Dp.1

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

REPORT ON THE BLACKHILLS BEETLE IN THE KAIBAB NATIONAL FOREST

By H.P. Blackman,
Bureau of Entomology,
U.S. Department of Agriculture

March 1926

GOVERNMENT PRINTING OFFICE

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Notes on General Habits, etc. of Dendroctonus ponderosae.

The following few notes on the habits and behavior of D. ponderosae perhaps contain very little previously unknown, but are here presented merely as a progress report which may be of some value as suggesting leads for future investigations.

In the latter part of May (May 28) when the writer began his field observations on the Kaibab National Forest, the greater percent of the brood of D. ponderosae were in the stage of "half grown" larvae. Some burrows contained very small larvae, apparently quite recently hatched, but well over fifty percent were about half-grown. A considerable number were nearly full grown, and another considerable number in the prepupal and pupal stages. The first newly transformed adults were found May 30, and from that time onward became increasingly numerous until by the middle of July larvae and pupae became quite uncommon in standing trees. During early summer up until the last of June it is not uncommon to find overwintered adults of the parent generation still alive in their burrows in the bark. Some of them certainly emerge and it is possible that a few of them reenter the bark of the same or of other infested or down trees and lay more eggs. However, they are never numerous enough to attack living trees successfully where an attack in numbers is necessary to overcome the flow of pitch. This is especially evident when we consider that yellow pine trees in the early summer seem to produce a much more copious flow of pitch than they do after the middle of July.

The young newly transformed beetles are at first nearly colorless but soon become tan, later brown and finally black. This acquisition of color is very slow in this species, however, and the young beetle does not become fully black until several weeks after transforming. The pronotum, head and legs attain the fully black color considerably sooner than the elytra and indeed a few beetles have been seen in flight and attacking trees in which the elytra were not yet fully black.

By the time the young beetles have become light brown in color, which would occur in a few days after transforming, they start feeding on the inner bark of their parent host. They enlarge the pupal chamber in which they transformed and, when the brood is heavy in a tree, the bark separating the burrows of adjacent young adults is eaten away in the course of a week or so and in such heavy brooded trees the larvae assemble in groups in the irregular feeding galleries. Often these groups include from seven to twenty-five young beetles. The formation of such groups was noted this year in heavily brooded trees as early as June 15. At this time also many of the groups had constructed galleries leading out nearly to the surface of the bark, but none were found actually penetrating the outermost layers until July 6. This date also coincides with the finding of the first attacks by D. ponderosae upon the felled trap trees, and of course means that emergence had actually begun slightly before that date. This early emergence was found only in extra-

dry, rather thin-barked trees which had been cut a week or two previously. Normal emergence this year began in the latter part of July and the first attacks upon standing trees in any numbers were found July 29 on trees surrounding trap tree of June 29. A few pitch tubes were seen on standing tree before this date, but the beetles were not in adequate numbers and were soon pitched out. The heighth of the attacks on standing trees near centers of normal emergence - i.e., in areas where the brood had not been hastened or retarded by the experimental treatments of September 1924 - occurred between the 10th and 17th of August.

During the period of attack several days were spent in attempting observations upon the flight of the beetles, their behavior during attack and upon their enemies during flight and attack. The observations made, although they are very fragmentary, are here recorded, as some of them may suggest leads which should be followed in later studies.

Flight. The observations on the beetles in flight were very few, fragmentary and unsatisfactory. Although considerable time was spent in trying to determine the direction of flight and the behavior of the beetles during flight, no satisfactory results were obtained. In all perhaps thirty D. ponderosae were seen in actual flight, but most of them were seen for only an instant and in such cases practically nothing could be determined except the general direction. Invariably flight, except when the beetles were in the center of a new

infestation, was in the general direction of the prevailing wind, which during the observations was always either from the south or southwest. Beetles were observed to fly in a fairly definite direction as they approached a new infestation. Then on entering the area of infestation they hesitate, often remaining nearly stationary in the air for a few seconds, or waver from side to side; then dart directly to a tree. They often strike the tree with force sufficient to produce a sharp tap which can be heard several feet away. In two cases beetles were heard to strike an uninfested tree in this manner and in each case that tree was found to show one or several pitch-tubes the following day.

On several occasions beetles were seen leaving newly infested trees which they had apparently found not to their liking. In each case their flight was diagonally downward for a yard or so. Then they paused in the air for an instant and either flew off with the wind or hovered about for a few seconds and darted to another tree. Several beetles were seen to leave an infested tree in one center of infestation, pause in the air for a moment and then fly directly toward another infestation center about 75 yards north.

One very great drawback to making observations on the beetles in flight lies in the fact that the light must be very good - i.e., sunlight - if one is able to keep them in sight for more than an instant at a time. The direct sunlight must strike the beetle at just the proper angle to the line of vision. Unfortunately the beetles seem to avoid direct sunlight to a certain extent and only a

few fly during bright days. They seem to prefer warm, cloudy or partly cloudy days or evenings from just before sundown to dusk. At such times it is nearly impossible to see them, although one may know they are present in considerable numbers by watching the birds capture them in mid-air. All observations lead to the conclusion that the time of day when maximum flight occurs is from mid afternoon to dark.

It has been stated that whenever the beetles were actually observed in flight they were proceeding in the direction of the wind. In one center of infestation which was under close observation during August the attacking beetles had not come from the south or west. In this case they had emerged from a group of trees felled in the experimental treatments of September 1924 and lying from about 100 to 200 feet north. That the beetles came from this treatment is indicated by the fact that no other trees within 200 yards in any direction could have produced beetles in sufficient numbers, and is practically proven by the progress of the infestation which began rather late (August 12) and was still in progress on August 26. This delayed attack points unmistakably to the origin of most of the beetles from the fall experimental trees covered with brush. In these trees the brood was so much retarded that even on August 26 when attacks elsewhere were practically complete, young adults were still to be found in trees of that treatment. This center of infestation was on an east slope near the apex of a ridge and was in such a location as to be measurably protected from the prevailing winds.

Behavior During Attack. On a number of occasions beetles were seen as they alighted or immediately after they alighted on the bark. In nearly all cases they strike the bark with such force as to produce an audible "tap". Often they strike in such a manner that they do not obtain a foot-hold but fall to the ground at the base of the tree. They then immediately crawl up the tree creeping along the crevices between the ridges of bark and apparently examining these crevices carefully as they go. More often, however, the beetles on striking the tree obtain a foot-hold. They then immediately scurry into the nearest bark groove and proceed slowly up the bark examining each bark-crevice carefully.

Having found a place to its liking (what determines the choice I cannot say) the beetle begins burrowing into the outer bark in a direction diagonally upward - i.e., not perpendicular to the bark surface. As it works, each bite of the mandibles produces a "ticking" sound which can be heard several feet away. (On several occasions trees were spotted by this "ticking" sound as being attacked although no pitch-tubes were present). This "ticking" can be heard at any time during attack up until the time when the beetle begins filling the portion of the burrow behind her with frass. The entrance gallery is carried diagonally through the phloem to the surface of the sapwood. On reaching the sapwood the gallery is curved to one side (usually to the right, but occasionally to the left) and upward. This curved or angled portion is usually about three-fourths of an inch long and then the burrow is straightened out and extended nearly directly upward. The completed

galleries vary in length from slightly over a foot to more than three feet, with the average well over two feet long. They usually groove the surface of the wood only slightly as most of their diameter lies in the inner bark.

The burrow is started by the female beetle and all of the work of tunneling is done by her - the male only assisting in the disposal of some of the frass and pitch. In starting the burrow the female works industriously and rapidly in penetrating the outer bark. In biting the bark she produces a "ticking" sound, each "tick" representing a bite of her mandibles. This "ticking" can be heard for a distance of several feet and when the beetle is working without hindrance from pitch or from other hampering factors the "ticks" can be heard at intervals of about a second. At intervals there is a pause as the beetle partly rotates in her burrow and thus presents a new surface to her mandibles. The product of this activity is soon seen as a rather coarse, brown "sawdust" which is cast out from the burrow and lodges in the crevices of the bark.

The early progress of the burrow is much more rapid than it is a little later. As soon as the entrance gallery penetrates the phloem and cambium of a living tree there is a more or less copious flow of pitch into it and this slows up further progress very materially. With the flow of pitch the further progress of the burrow is slowed up in proportion to the amount of pitch-flow, which in turn seems to be governed by the vitality of the tree and by the ratio between this vitality and the number of beetles attacking. If the pitch flow is great and the number of beetles attacking the tree is too small the

result is the "pitching out" of the beetles. The expression " pitching out" means either that the attacking beetles are drowned in the pitch or that they are discouraged by the copious flow and abandon the burrows already started.

In vigorous trees the first flow of pitch from pitch tubes is usually white or slightly creamy in color, and so continues until the resistance of the tree is at least partially overcome. When the attack is about to overcome the trees' resistance (or in unvigorous trees from the very start) there is a flow of thicker reddish pitch. This is succeeded by a mixture of red pitch and red boring dust and this in turn by red boring dust. This red "sawdust" is merely the frass derived from the innerbark, containing some pitch but not enough to agglutinate the particles into a pitch-tube. The appearance of considerable quantities of this red boring dust about the bases of infested trees seems to be an infallible sign that the resistance of such trees has been overcome and the attack of the beetles has proven successful.

Where the attack on a vigorous tree produces a copious flow of pitch the beetles even when attacking in considerable numbers will work for a week or more without accomplishing very much in the way of extending their burrows. But apparently they are all the time striving to keep the entrance gallery open and to drain the short gallery of the constantly flowing pitch. Observations were made on a number of females to discover the methods they use in handling the pitch. In all cases the observed beetles were working in a strong flow of white pitch in burrows not far advanced. The behavior of all

was very similar and the notes on one beetle given below may be considered as typical of several under observation.

Observations were made on a burrow about 6 feet from the ground on a small vigorous 9" tree showing 8 pitch tubes. The first signs of attack had appeared the preceding day. All of the attacks produced a copious flow of white pitch which was usually so liquid that it formed not a typical pitch tube, but produced a sort of shelf just below the entrance. The female beetle under observation was first seen to come out of the entrance gallery backward forcing a considerable quantity of pitch behind her and with her whole body apparently thickly covered with it. She backed out on the platform of hardened pitch below the entrance, waded about in the pitch she had brought out and spread it in a thin layer to the very brink of the shelf. Then she crawled from the pitch platform to the bark at one side of the burrow-entrance, wiping off the still adhering pitch by spreading it over the adjacent bark and allowing it to drain from her body. Then she went into her burrow again, but immediately backed out with another mass of adhering pitch and exactly repeated her previous routine. This was repeated several times, resulting in the disposal of the pitch which had accumulated in her burrow. Then the beetle entered the burrow and could be heard making the characteristic ticking sound due to biting of bits of the inner bark. The end of the elytra could just be seen through the burrow entrance and the beetle could be seen bracing itself against

the side of the burrow and apparently working hard. This continued for 2 minutes and then the worker again backed out and spread the pitch as before and repeated this three more times going through the same routine each time. This alternate boring and pitch disposal continued at irregular intervals as long as the beetle was under observation. In boring the beetle works either with its back up or down or lying on its side.

Very few observations were made upon the behavior of the males during attack but a few points of interest were noted. On numerous occasions males were seen creeping over the bark of infested trees and examining the bark crevices carefully. Several times one or more males were seen near newly started burrows which had not yet tapped the pitch. They apparently merely loaf around near the working female until her burrow penetrates the bark deeply enough to accommodate both of them. Then the male will often take up its position at the opening of the burrow and help in the disposal of the boring dust.

On one occasion a newly started burrow from which brown "sawdust", derived from the outer bark, was being pushed out, was found. This burrow contained a female and on the bark surface near the entrance two males were apparently fighting. They were pushing each other about with their heads like little bulls. Finally one of the males succeeded in pushing the other away for some distance, and then immediately moved over and tried to enter the burrow. This, however, was as yet too shallow to accommodate the female and male too, so

that nearly half of his length protruded. The other male immediately pursued him and butted him from the rear. The one in the entrance pushed back with his body strongly and suddenly and succeeded in shoving the other entirely off of the bark and he fell to the ground at the base of the tree. He immediately began to ascend the tree again. Males were often seen ascending infested trees in this manner and it is probable that many of these are individuals who have lost out in their battle for a female.

On several occasions a shrill stridulation could be heard coming from certain burrows. This in each case showed the presence of a male, as the female appears to have no stridulating organs. In no case did stridulating continue very long, but soon ceased, to be immediately succeeded by the "ticking" sound, showing that the female had resumed its work upon its tunnel.

Enemies of Dendroctonus ponderosae During Flight and Attack.

During the heighth of the flight of D. ponderosae a part of several days was spent in observations upon the beetles in flight and their enemies during flight and attack. These few observations were made August 14, 15 and 16. At this time the large Clerid beetle (Enoclerus sphegeus Fab.) which was extremely numerous in the latter part of May and throughout June was still on the wing but was much less numerous than earlier in the summer. There was certainly not more than 4% as many about in the middle of August as were in flight two months earlier. This Clerid could have but little effect upon the beetle during its period of attack and flight. However, my ob-

servations this year lead to the conclusion that two species of birds are a rather important factor in reducing the number of D. ponderosae at this time. Perhaps this factor is not of much effect during times when the beetle epidemic is on the increase or holding its own, because at such times the beetles are so extremely numerous that the few thousands or few hundreds of thousands eaten by birds would represent only an extremely small percent of those attacking. But at times, such as this season, when the numbers of beetles are strongly on the wane the percentage killed by birds is much increased - although the actual number consumed is perhaps considerably less. Of course, the good accomplished as measured in number of trees saved would in either case be in direct proportion to the number of beetles actually eaten, but in years of heavy epidemic the percentage of trees saved to the number killed or of beetles eaten to those surviving would be very small, whereas under endemic or light epidemic conditions the percentage would be increased many times. Thus these birds, while of little effect in controlling an epidemic, must be of considerable benefit in keeping the status quo under endemic conditions of infestation.

The two birds which were observed feeding heavily upon D. ponderosae are the mountain blue-bird and the western nut-hatch. The blue-bird preys upon the beetles during their flight and catches most of them on the wing. During most of the day, but especially during the afternoon numbers of these small birds were to be seen perched at

various points of vantage in and near a center of new infestation. They were present in varying numbers - sometimes more than a dozen being under observation while at other times less than half this number were present. At first they were rather suspicious of the observer but soon became accustomed to his presence and would often perch within a dozen feet of him. From their points of vantage they would observe the beetles in flight and would dart out, flutter a moment in mid-air and capture their prey on the wing. Occasionally also a blue-bird would fly to the bark of some newly infested tree, cling precariously to the rough bark for an instant and capture some insect upon the bark surface.

While there was strong presumptive evidence that the chief interest of the birds in this center of new infestation was furnished by the beetles of D. ponderosae flying to attack the trees, direct and absolutely certain evidence that they were capturing any large number of this particular species was lacking. As we had no permit allowing us to kill the birds to examine their crop-contents, the birds were kept under close observation and whenever they were seen to defoecate their dung was collected. An examination of their dung later showed that well over 60% by bulk of the solid matter consists of the remains of D. ponderosae. Other recognizable insect parts in the dung consisted of the remains of Ips sp., Hylurgops subcostulatus, an unknown Bostrychid and portions of unknown small moths.

The nut-hatches were not so numerous as the blue-birds nor did they remain in the center of infestation so long a time. But this was more than compensated for by their greater efficiency and activity while they were present. They work in an entirely different way from the blue-birds. Very seldom did they capture an insect on the wing except when they had succeeded in dislodging one from the bark crevices. They made a rapid but apparently a thorough examination of the bark crevices ofevery newly infested tree and also of adjacent trees not yet known to be attacked. Much of their prey was found in bark crevices before the beetles had succeeded in boring in but perhaps 25% were dug out of newly started burrows - burrows which had not yet tapped the inner bark, as shown by the absence of any pitch tube. One bird was kept under observation for 3 minutes and during that time captured 20 insects - nearly all of which were certainly D. ponderosae. This is an average of more than 6 insects per minute and at this rate the appetite of the small nut-hatch is soon temporarily satisfied.

The fresh bird dung of a number of nut-hatches under observation was collected. A later examination showed that well over 75% of the bulk of the dung consisted in the remains of D. ponderosae. Other insect remains present consisted in portions of unknown moth, Ips sp., one H. subcostulatus (1 elytron, 1 pronotum and 4 legs identified) and portions of some unknown small beetle. Nearly 20 dung pellets of nut-hatches were examined and the estimated percentage of Dendroctonus remains varied from 60 to 95%.

Other birds other than these two were quite numerous near and on the felled trap-trees. Considerable numbers of an unidentified warbler were often perched on and about this material, but observations soon showed that they were not interested in the Dendroctonus, but in smaller beetles such as Ips oregoni, Pityophthorus sp., Pityogenes carinulatus and the accompanying scavengers and predators such as Hypophloeus sp. which were numerous in flight at the time.

It is recommended that in the future a more thorough investigation of the influence of various birds upon D. ponderosae be made. This should include the woodpeckers and others observed upon infected trees during the early summer before emergence of Dendroctonus has begun; a study of the crop-contents of various birds occurring in centers of strong emergence during the emergence of the beetles; and also a more thorough study of birds occurring in and near centers of attack. It is apparent that such a study could not be done advantageously without killing a number of birds and examining their crop-contents, before the insects have become so disintegrated by the process of digestion as to render it too difficult to identify them, and to estimate the proportion of the various food elements.

Factors Governing Attacks by Dendroctonus ponderosae

Choice of Trees for Attacks by Beetles. General observations upon the Black Hills beetle covering a period of many years by Messrs. Edmonston and Hofer have brought them to the firm conviction that the beetles in attacking trees show no discrimination as to the relative vigor of the tree attacked. My own observations this season on the trees attacked by the beetles in 1924 and 1925 lead me to the same conclusion. The choice of the first tree in a group seems to be entirely a matter of accident and the later trees in the group are filled in in the same manner regardless of their vigor as judged either by general appearance or increment growth.

The location of the center of attack may, however, be controlled in many cases by felling a trap tree. Many beetles are attracted to it and attack it. They may completely fill it or they may only partially fill it. However, if such a tree is near a center of heavy emergence or in the course of a heavy flight, the surrounding trees will almost certainly be attacked and these are filled in without regard to the vigor of the tree, those nearest the trap tree being attacked first. Of course, enough beetles must be present or the attack on a large vigorous tree will not be successful. Just so will the attack upon a weaker tree be unsuccessful unless a sufficient number of beetles are present. It seems logical to believe that a weak, slowly growing tree has less resisting powers and will

require fewer attacks per square foot to overcome its resistance than will a vigorous rapidly growing tree. So far as is known, however, this has never been proven either by observations or by experiment.

Mr. Keen has made the statement (verbally) that the first tree attacked in a group was less vigorous and showed slower growth than those later attacked in the group. In arriving at that conclusion he assumed that the first tree in a group to fade was the one which had been attacked earlier. That did not seem at all logical to me, as one would naturally expect the most slowly growing tree of a group to fade first as its water conducting tissues would be least efficient and the foliage would naturally dry out sooner. Thus it would be the first to fade even though the tree might have been killed days or even weeks later than other rapidly growing trees nearby which still possessed fully green foliage.

To test this out and determine if vigor as determined by increment had any relation to the sequence of attack in a group killing, increments were taken in two small groups in which the date of attack was known for each tree. The increments in both groups were taken August 28, 1925.

The first group consisted of five trees varying from 18 to 28 inches D.B.H. near the base of a west slope. All of the trees appeared to have been vigorous and none were especially slow in their growth. The sequence of attack of the first two trees is not known as both were spotted on the same day and both were about equally full.

No. 1 (or 2)	Spotted	8/6/25	Increment last	half	inch	16	yrs.
No. 2 (or 1)	"	8/6/25	"	"	"	10	"
No. 3	"	8/6/25	"	"	"	20	"
No. 4	"	8/14/25	"	"	"	16	"
No. 5	"	8/15/25	"	"	"	7	"

A similar small group of 5 trees were studied on the east slope of the same hill.

No. 1	Spotted	8/12/25	Increment last	half	inch	17	yrs.
No. 2	"	8/15/25	"	"	"	9	"
No. 3	"	8/19/25	"	"	"	9	"
No. 4	"	8/22/25	"	"	"	12	"
No. 5	"	8/22/25	"	"	"	9 1/2	yrs.

In this last group the source of the beetles attacking the first tree seemed apparent. They doubtless came from a small tree only 6 feet away from the one attacked - the nearest other source of emergence being over 200 feet away. The tree first attacked was the one nearest the source of emergence and that perhaps accounts for the choice of the first tree attacked rather than its slower growth. The other trees were from 2 to 4 times as far away.

It would seem then that there is evidence to believe that the vigor of a tree as represented by its increment has no bearing on its choice by the beetles for attack. This is also strongly evidenced by the experiments tried by Mr. Edmonston over a period of years of placing young beetles upon the bark of trees. They invariably bore in and nearly invariably kill the tree. One which was killed in this manner in 1924 showed an increment of 10 years to the last half inch and another so killed in 1925 showed an increment of 13 years in the last half inch. They were both young vigorous trees with considerably higher than the average growth.

Once a tree is attacked it exerts an attraction on other beetles and the later arrivals continue to attack that tree until it is fully occupied. Others coming later attack nearby trees regardless of their vigor so long as they are either still living or recently felled. Some experiments were started this year in attempting to find out what induced this concerted attack and what factors acted as attractive agencies.

Experiments in Inducing Attacks

The trap tree experiments have shown us that the only sort of trap trees tried which gave any consistent results in inducing attacks by Dendroctonus ponderosae were the felled trees. The attractive influence of such trees was already known before this year's experiments were tried and has been made use of in the past (as in the Powell and Dixie National Forests) in recommending active logging during the late summer as a measure in preventing the building up of epidemic conditions and as one measure in the control of weak epidemics. Trees hack girdled or belt girdled apparently offer no more attractions to the beetles than do untreated trees and when attacked do present some difficulties to the beetles not true of untreated trees. In fact, in several cases it seemed as if girdled trees were actually avoided by the beetles which showed a preference for untreated trees near at hand. That seemed particularly true of trees which had been girdled two or more months previous to the flight of the beetles.

Naturally the question arose as to why there is this apparent discrimination against girdled trees. Is it due to some physiological quality or condition of the tree - such as sap density? Or is it possible that it might be due to the odor of the partially dried pitch which had exuded in copious quantities from the trees girdled early in the season. That the latter might be true was hinted at by the fact the beetles showed a similar slight aversion (not entire avoidance) to trees which had been unsuccessfully attacked the previous year - such trees being more or less covered with the old partially dried pitch tubes.

To determine if the old partly dried pitch from girdled trees exerted any attractive influence in inducing beetles, a considerable quantity of white pitch was taken from a hack girdled tree treated April 29, 1926, and was smeared over the bark of two trees about 100 yards from a center of strong (for 1926) emergence. One of the trees chosen was 7" D.B.H. with a medium light crown and corky bark. It was on a west slope with the area of beetle emergence to the south and west of it - the nearest old infestation being about 100 yards away. The prevailing winds were from the south and west. The tree was treated August 17 by smearing small dabs of the partly hardened pitch upon the bark from 4' to 7 1/2' from the ground.

Another tree near this of 11" D.B.H. with rather thin corky bark and a rather light crown was treated in a similar manner. In handling the pitch it was noticed that it had a rather strong rank odor similar to turpentine and not at all like the much more delicate odor of fresh pitch or of newly made pitch tubes. The more volatile elements had largely evaporated from it.

The results from these two trees were entirely negative. No attacks occurred. This, however, proves nothing as negative results should never be considered as proof but only as evidence depending for its strength upon the number of the experiments and the consistency of the results. When the experiments were made, positive results, i.e., attacks, were not expected as it was believed that old pitch would have no attractive influence upon the beetles. If there is an attractive influence in the odor of pitch (and there must be, as otherwise why should freshly cut timber invariably attract the beetles?) the attractive elements are the more volatile essential oils which soon evaporate from the fresh pitch and result in its partial hardening - leaving only the more solid elements and the rather odors.

Another tree, several hundred yards from any emerging beetles and in a region (Three Lakes) where recently killed trees (1924 attacks) were few in number, was smeared with dabs of fresh semi-liquid pitch from the stump of a newly felled tree of the 1925 infestation. These were placed at intervals of 6-8 inches on the bark of the tree from 8' - 7' from ground. No attacks were induced. This again is negative evidence only and is of no value as only the one tree was tried and the experiment was started August 19, when the beetles were still in flight but after the various centers of normal attack had been well established. Various modifications of this experiment should be tried next year. Suggestions made later.

A third set of experiments were made by smearing the trunks of trees with small dabs of pitch obtained from pitch tubes taken from trees which had been recently and successfully attacked by the Bilok

Hills beetle. The first tree (T-1) was treated August 17, 1925 at 2.30 P.M. This tree described as follows - 12" D.B.H.; Bark scaly-corky, medium thin, moderately ribbed; Bole 35 ft. clear of limbs; Crown medium light; Increment last half inch, 17 years. The tree was located about 100 yards from the nearest trap trees, about 100 yards southeast of a known center of new infestation. There were also two other centers of new infestation near - of which nothing was known at the time. One was 120 yards north and the other 85 yards northeast. Several hundred trees containing emerging brood occurred within a radius of 300 yards - the heaviest brood being about 200 yards southwest.

This tree was smeared with dabs of fresh pitch-tubes from a distance of 3 to 7 1/2 feet from the ground. The pitch chosen was partly white, partly red and partly mixed with "boring dust". On August 19 at 9.30 A.M. the tree was examined casually and no evidence of beetles or their work was discovered. The tree was then in entire shade on a cool morning. At 11.20 A.M. a more careful examination was made. No pitch tubes were present but several beetles could be distinctly heard working in the bark, producing the characteristic "tickling" sound. About 3 feet above the ground on the west side a quantity of red bark "boring dust" was found in a bark crevice and more was seen coming from an entrance above. Two male beetles were observed near the entrance, pushing or "butting" each other with their heads. One was finally successful in pushing the other off the bark and immediately tried to enter the burrow being made by the female.

On August 20, two pitch tubes were present on the west side of the tree - one being the burrow started the previous day. Seven male beetles were observed wandering about over the bark. I could distinctly hear a stridulating noise coming from the first burrow started and known to contain a female and male. This noise soon ceased and the beetle resumed work as indicated by the characteristic "ticking" sound. On August 25 seven pitch tubes were present - all but one on the west side. No further attacks occurred up to September 1st and most of the burrows were abandoned by August 29 when only one was still open.

Experimental Tree T-2 at Three lakes was treated in a similar manner. The description for this tree follows - D.B.H. 12"; Bark corky, medium thick; Crown medium; Increment last half inch - 11 years. This tree was smeared with pitch tubes from 3 to 7 feet up 2.00 P.M., August 19, 1925. It was located several hundred yards from emerging beetles in a poorly infested area. It was examined August 30 and no attacks were found.

Experimental Tree T-3 at Three lakes. Tree 11" D.B.H.; Bark corky, medium thick; Crown light; Increment last half inch - 40 years. Treated similarly August 19, 1925. Located 150 yards southwest of T-2. No old or new infestation within 200 yards. When examined August 30 it showed one attack, 3 feet from the ground on the south side.

Experimental Tree T-4 at Mile and a Half. Tree 8" D.B.H.; Bark moderately thick, corky-scaly, ribbed; Crown rather light; Bole 30 feet clear of branches; Increment last half inch - 24 years.

This tree is about 30 feet north of T-1. It was treated August 21 (too late). No pitch tubes appeared on this tree up to September 1st.

While these experiments did not result in the thorough infestation of any one of the four trees, an analysis of the experiments would seem to give some interesting facts and to suggest interesting future experiments. In the first place, while none of the trees were killed by the beetles, the experiments with fresh pitch tubes did induce attacks in two of the four trials. It is believed that if the trees had been more favorably located and if the experiments had been started earlier in the flight of the beetles the results would have been more striking and consistent. In the case of the two trees at Three Lakes the experimental trees were purposely chosen as far as possible from an infested tree of 1924. So any attack by the beetles would indicate a flight of several hundred yards from their point of emergence. Unfortunately, however, the experiment was started August 19 at which time most of the brood of beetles had already emerged and those which had emerged had already attacked trees and established the centers of infestation for the season. Thus even the single attack indicates some attractive influence exerted by the pitch tubes.

In the cases of the two trees at Mile and a Half the conditions of the experiment were also quite unfavorable. Experimental Tree T-4 was started August 21, too late for anything but the remnant of the flight. In the strong centers of attack (except near the experimental treatment of September 1924 on East Ridge) very few trees were newly infested after August 20, 1925, up until September 1. (Mr. Edmonston also informs me that no new trees have been attacked since

September 1st). Also both this tree and T-1 were so situated that 3 very strong centers of new infestation, and therefore centers of attraction, were from only 85 to 120 yards distant. These three centers of attraction were active at the time the first tree of this series was established - although but one of them was known of at the time - and a number of new trees were infested and filled in from August 17 to 20. In one of these groups ten trees were attacked during that period - the period from August 15 to August 20 being the period of maximum flight in this particular area. Thus it would appear that the conditions of the experiment were very unfavorable and the fact that one of the trees at Mile and a Half was attacked shows that a rather strong attractive influence is exercised by the recently made pitch tubes.

To what is this influence due? Undoubtedly to some odor. What is the attractive odor in this case? Is it the odor of fresh pitch or is it the odor of some secretion or excrement left in the pitch tubes by the beetles? That is a question which will require further investigation. It is believed that the odor of fresh pitch does exert an attraction to the beetles - especially to the females - and this should be determined by further experiments in later years. It is believed, however, to be quite significant that the earliest beetles attracted to the tree T-1 were predominately males. Thus on August 20 but two new pitch tubes had been constructed, they being occupied by females, while seven males were observed wandering about over the bark. This would seem to show a stronger attraction to males than to females and this stronger attraction for the males may be due and probably is due to some odor left in the pitch-tubes by some secretion

from the female beetles while these pitch-tubes were still on the original trees.

Suggested Experiments in Inducing Attack

It is felt that in future years a series of experiments should be carried on testing out various possible methods of inducing attack. A number of such experiments are suggested in the following paragraphs.

Experiments with Old Pitch. Only negative evidence was obtained by the two experimental trees this year. No attacks were induced and perhaps none will be induced in future experiments under like conditions. However, similar experiments with variations as to material used and as to the location and surroundings of the experimental trees should be tried. Pitch from injuries of different ages (from one to four months' exposure to evaporation) should be used. Also fresh pitch collected at various times in the summer and kept in air tight containers to prevent loss of the volatile elements should be used. The reason for this is that the flow of pitch from trees injured early in the season is very copious, while that from wounds made after the middle of July is relatively scanty. It is probable that there may be a seasonal variation in the amount of certain elements in the pitch as well as in the quantity.

This pitch from various sources should be smeared on trees in different surroundings: (1) Trees distant from any area of emergence and of fresh attack. (2) Trees near area of emergence but distant from area of fresh attack. (3) Trees near or in area of fresh attack. These experiments might give evidence of value. For

instance, if the old pitch exerts a strong attraction it might induce attack at a distance from either active emergence or active attack. If it offers only a weak attraction it might induce attack only near a center of strong emergence.

Finally the experiment in or near a strong center of attraction would give evidence as to whether the old pitch exerted an attraction (if the tree were attacked earlier than other untreated trees nearer the center); whether it exerted a repelling influence; or whether it had no effect in either way.

Experiments with Fresh Pitch. Experiments with fresh pitch should be made under similar conditions of situation and surroundings of the experimental trees as with the old pitch. It is believed that the fresh pitch will exert an attractive influence and experimental trees should be established at varying distances from both centers of emergence and attack. Also such experimental trees should be prepared at about the time of emergence and at various intervals shortly before the time of emergence of the beetles, to see if the location of centers of attack can be controlled in this manner. There would seem to be a fair chance of success but it is questionable as to how great a distance the attractive influence (if such exists) would extend.

Experiments with Fresh Pitch Tubes. There can be no doubt that a recently attacked tree exerts a strong influence on the beetles in the vicinity and induces attacks by them either in the tree already attacked or in others adjacent to it. To what is this due? Is it due to the odor of the beetles themselves, to the odor of the pitch, to the odor of certain secretions or excreta in the pitch tube? By means of this experiment, the experiment with fresh pitch and of others to be suggested later, we should be able to get some evidence to aid in answering the questions.

The experiment with fresh pitch tubes attempted this year under very trying conditions would seem to indicate that the pitch tubes do offer an attraction to both male and female beetles - but perhaps a stronger attraction to the males. These experiments should be tried again and varied both as to the location and the surroundings of the experimental trees and as to mode and place of application of the pitch tubes. In this year's experiments all of the attacks induced were low down on the tree - most of them, and all of the first attacks - being either below or in the lower part of the treated portion of the tree. The pitch tubes should be smeared at varying heights on the tree - the probabilities being that a treatment of the higher portion of the tree will be more effective as it will allow better diffusion of the attractive odor and allow greater room for attacks below the treatment. Also there seems to be a region in the tree from 10-20 feet above ground in which the pitch tubes found are smaller than those above and below it.

The experimental trees should be placed at different distances and in different directions from a strong center of emergence to determine strength of attraction and direction of flight. They should be placed in various relations to centers of attack to determine priority of attack of treated and untreated trees. Other variations of the experiment may occur to us later.

Experiments with Caged Beetles. Is there some odor given off by the beetles themselves which acts as an attraction to others and induces concerted attack? A number of beetles should be caged and the cage suspended from a tree at some distance from the ground to see if the mere presence of beetles produces an attraction. They could be packed in slightly moistened cotton or moss (moss would have to be shipped in) to prevent too rapid drying. Others could be caged with bark from their parent host tree. Still others could be caged with fresh bark.

The latter method would nearly surely induce attack as it would include all of the probable attractive influences- pitch, beetles, secretions, excreta.

Experiments with "Grafted" Beetles. For a number of years Mr. Edmonston has induced attacks upon trees by removing a number of young beetles from their parent galleries and placing them in crevices of the bark of vigorous trees. The trees were invariably attacked and usually killed. This year the experiment was conducted more critically and more detailed data kept as to the results. A

small vigorous tree was chosen in the midst of a recent killing (1922-1923) which showed a vigorous growth (increment last half inch - 13 years). 175 beetles were placed on it and frequent records of the number of pitch tubes were taken, the tubes being dated as they appeared. In the latter part of August 220 attacks has been recorded. This means that a considerable number of beetles from outside had been attracted to the activities of those placed on the tree.

Use of this method of indexing attack can be made in obtaining evidence as to the direction and distance of the flight of the beetles. Such experimental trees can be prepared at different known distances and in different directions from centers of emergence. The excess of attacks over the number of grafted beetles can be determined and conclusions drawn both as to direction and distance of flight.

This will involve a very thorough preliminary scouting and perhaps an early control treatment of some trees in order to obtain trees at known distances from any infestation. With the great decrease in the infestation, this will probably not be so difficult for the next few years as it would have been in the immediate past. This experiment gives promise of furnishing an answer to two questions which are very important in control operations - namely, how far do the beetles fly and in what direction is their principal flight.

Brood Counts of D. ponderosae in Entire Trees.

During the middle of June several trees, ten or twelve in all, were felled and the bark examined so as to obtain a general idea as to the condition and number of the brood. Two of these were completely stripped of bark and all of the brood of D. ponderosae was preserved and later counted. One of these trees contained a light brood and the other a heavy one. At that time it was planned to continue this system with a number of trees a few weeks later in order to get an accurate idea of what to expect in the way of emergence and attack for the season of 1925. Later the plan was changed and a large number of trees were felled and an average of between 9 and 10 square feet from each was examined, with the same end in view. The report on these later counts is already in your hands. The counts on the two entire trees mentioned above offer some points of interest, however, and are therefore presented.

The first tree (x-2) on which complete brood counts were made was felled June 12. It was 19" D.B.H., nearly average size for the forest. The crown was rather light, bark corky, moderately thin, very dry and quite tight for the most part. The trunk was infested to a height of 26 feet above the stump. The bark was removed in approximate quadrants according to the points of the compass and counts of attacks and living brood were kept for each quadrant.

The tree was on a west slope, exposed to the drying action of the wind and was exposed to the sun during the morning and up until noon. Therefore one would expect the greatest amount of sun kill

(if any were shown) on the East and South sides. The bark showed considerable effective work by both cerambycids and wood-peckers, although the cerambycid larvae at that time had only begun their most efficient work. Apparently they were at the beginning of the last larval instar - as judged by size only.

The data is given below -

North quadrant of trunk.

Bark surface 9" x 26' = 19.5 sq. ft.

Larvae	135
Pupae	162
Adults	0
	297

Average brood per square foot 15.28

Parent galleries - 84 - 4.3 per sq. ft.

Beetles attacking - 168 - 8.6 per sq. ft.

Excess of brood over parents - 129 - 6.6 per sq. ft.

West quadrant of trunk.

Bark surface 11" x 26' = 23.83 sq. ft.

Larvae	162
Pupae	189
Adults	4
	355

Average brood per square foot - 14.89

Parent galleries - 139 - 5.83 per sq. ft.

Parent adults - 278 - 11.66 per sq. ft.

Excess of brood over parents - 77 - 3.2 per sq. ft.

South quadrant of trunk.

Bark surface 10" x 26' = 21.66 sq. ft.

Larvae	56
Pupae	87
Adults	9
	152

Average brood per square foot - 7.01

Parent galleries - 83 - 3.8 per sq. ft.

Parent adults - 166 - 7.6 per sq. ft.

Deficiency of brood - 14 - .64 per sq. ft.

East quadrant of trunk.

Bark surface 14" x 26' = 30.33 sq. ft.

Larvae	39
Pupae	47
Adults (young)	49
	135

Average brood per square foot - 4.45

Parent galleries - 105 - 3.46 per sq. ft.

Parent adults - 210 - 6.92 per sq. ft.

Deficiency of brood- 75 - 2.47 per sq. ft.

Totals for the tree x-2

Bark surface - 95.33 sq. ft.

Total brood for tree - 939

Average brood per sq. ft. - 9.85

Parent galleries - 411 - 4.31 per sq. ft.

Parent adults - 822 - 8.62 per sq. ft.

Excess of brood over parents - 117 - 1.22 per sq. ft.

The other tree on which a complete brood count was made was felled June 17. It was a rather rapidly growing tree 28" D.B.H. and 85 years old on the stump. The crown was heavy and still partly green, the sapwood quite full of water and showed less than 25% bluing. The bark was corky and medium thick, loose and moist. The attacks on the lower 6-8 ft. of the trunk were for the most part "pitched out" and this part showed heavy spring attack by Ips integer and Hylurgops subcostulatus. Above 32 feet from the stump the bark was green where not destroyed by the burrows of D. ponderosae, Ips integer and Ips oregoni. Only the lower 32 feet of the trunk was used in the counts because of the few Dendroctonus and many Ips above that level.

The log was laid off as accurately as possible into quadrants and counts made on this basis. The tree was so situated that the trunk was shaded most of the day except during the early morning hours, and was well protected from the drying winds by dense growths to the south and west. The bark contained many cerambycid larvae and these were just beginning their most effective work.

North quadrant of trunk.

Bark surface - 49 sq. ft.

Larvae	175
Pupae	324
Adults	282
Total brood	781

Average brood per sq. ft. - 15.94

Parent galleries - 212 - 4.32 per sq. ft.

Parent adults - 424 - 8.64 per sq. ft.

Excess of brood - 357 - 7.30 per sq. ft.

West quadrant of trunk.

Bark surface - 49 sq. ft.

Larvae	243
Pupae	562
Adults	396
Total brood	1201

Average brood per sq. ft. - 24.51

Parent galleries - 230 - 4.69 per sq. ft.

Parent adults - 460 - 9.38 per sq. ft.

Excess of brood - 741 - 15.12 per sq. ft.

South quadrant of trunk.

Bark surface - 49 sq. ft.

Larvae	250
Pupae	600
Adults	314
Total brood	1164

Average brood per sq. ft. - 23.75

Parent galleries - 248 - 5.06 per sq. ft.

Parent adults - 496 - 10.12 per sq. ft.

Excess of brood - 668 - 13.63 per sq. ft.

East quadrant of trunk.

Bark surface - 49 sq. ft.

Larvae	137
Pupae	177
Adults	644
Total brood	1008

Average brood per sq. ft. - 20.57

Parent galleries - 248 - 5.06 per sq. ft.

Parent adults - 496 - 10.12 per sq. ft.

Excess of brood - 512 - 10.45 per sq. ft.

Totals for tree x-4.

Bark surface - 196 sq. ft.

Total brood for tree - 4154.

Average brood per sq. ft. - 21.19

Parent galleries - 938 - 4.78 per sq. ft.

Parent adults - 1876 - 9.56 per sq. ft.

Excess of brood over parents - 2278 - 11.63 per sq. ft.

It is believed that an average of the brood in these two trees represents very nearly an average brood for all trees in the vicinity of Mile and a Half at the time the counts were made - June 12-17, 1925. This opinion is based on observations made by felling and taking samples of ten or twelve trees. The first tree x-2 was chosen as representing a particularly weak-brooded tree and the other x-4 as representing a heavy brooded tree. If the broods are averaged it is found that the average brood per square foot is 17.48. But the average brood for standing trees at Mile and a Half East ridge on July 12 was 6.172. The difference between these two averages is believed to represent rather closely the mortality of the brood of D. ponderosae between the middle of June and the middle of July. This difference is 11.31 per square foot or a reduction of about 66%.

When we inquire into the reasons for this sudden and drastic reduction in brood we soon find that several important factors and perhaps many others of lesser importance are involved. The

most important factors are apparently three in number - (1) the drying out of the bark, (2) woodpecker work and, (3) the work of cerambycid larvae. Other less important factors consist in the activities of the larvae of clerids, trogositids and a fly (apparently Medeterus sp. or near that).

The first factor - that of the drying out of the tree - is most important in small or medium sized trees having thin or medium bark and a light to medium top. It is especially efficient in killing the brood in trees having the scaly type of bark. The drying out also is most noticeable in trees where a considerable percentage of the bark surface has been worked upon by wood-peckers. Indeed, I believe that more brood of D. ponderosae were killed this year by the more effective drying out of the bark by reason of woodpecker work than were killed directly by the woodpeckers in feeding. The killing effect of the drying out of the bark began early in June and was quite noticeable by the middle of that month as is shown by the tree x-2 studied above. Even at this date there was in this tree an excess of brood of only 1.22 per square foot over the beetles attacking. Had this tree been examined a month later it would nearly certainly have shown an average of less than 3 beetles per square foot - probably considerably less - due to the continuation of the drying out.

The efficiency of the woodpeckers as a factor in reduction of the brood is impossible to state without a thorough investigation. They are not especially numerous on the Kaibab and those

present seem to devote most of their efforts to a relatively few trees. It is questionable just how much of the brood they do destroy and the only way this can actually be determined is by a thorough study of their stomach contents. It seems certain that they do not specialize upon the Dendroctonus larvae but also eat clerids, trogositids and cerambycids. Thus there might be a question as to whether their actual feeding does good or harm. If we can determine how many Dendroctonus larvae would on the average be destroyed by each cerambycid, clerid and trogositid and then determine what proportion of the woodpeckers' food consists of these beneficial agencies, we might be able to decide the case either for or against the woodpecker. However, there can be no doubt that the indirect effect of the woodpecker's work is good in that it assists in the drying out of the bark.

In large, thick-barked trees the most important factor in natural control operative this year seemed to be the larvae of certain cerambycids. They acted as robbers, destroying the inner bark which would otherwise have served as food for the brood of Dendroctonus and also perhaps very often destroying the brood as well. The result of cerambycid larvae work upon Dendroctonus brood is of not much importance in the spring and early summer, but about June 15 the roundhead larvae have attained a considerable size and are probably in the last instar. During this instar they appear to eat considerably more food than during the rest of their larval life and it is not at all uncommon to find large trees in which from

75% to 95% of the inner bark has been chewed up by these larvae. In a fully infested tree a correspondingly large proportion of the Dendroctonus brood is also incidentally destroyed.

There are several species of cerambycids whose larvae are found in yellow pine on the Kaibab along with those of D. ponderosae. Of these Graphisurus (Acanthocinus) spectabilis is by all odds the most important. It is present in largest numbers and is a most efficient natural control factor in large thick-barked trees, but also occurs in smaller trees. It breeds in the trunks especially and thus occurs in largest numbers where it can do the most good. Graphisurus (Acanthocinus) obliquus is smaller and occurs in thinner barked trees and in the upper trunk and limbs of larger trees. Therefore it is not so valuable as a natural control factor. In some trees also are found large numbers of the larvae of Asemum sp. (probably atrum), Tetropium sp. (probably velutinum) and Monochamus sp. (probably maculosus) and others, but G. spectabilis is certainly more efficient than all of the others combined.

These two trees which are believed to be typical ones for this region of the forest - one typical of low brooded trees and the other of high brooded trees - yield further material for speculation and suggestions for possible future investigation. They were chosen for detailed counts not only because they showed nearly the extremes in the condition of the brood, but also because they showed striking differences as regards degrees of dryness of the foliage and bark and equally great differences as regards exposure to wind and sun.

Thus tree x-2 was chosen not only because examination showed a light brood, but because the leaves were all yellow, the bark and wood well dried out and because it was exposed to direct sunlight during at least half of the day and fully exposed to the prevailing south and southwest winds. In a like manner tree x-4 was chosen not only because it had a heavy brood but because the leaves were still partly green, the bark still rather moist and because it was well protected from the prevailing winds and not exposed to direct sunlight except during the early morning hours.

The brood counts being taken by quadrants should show some correlation with regard to exposure to sun and wind, provided these are actually important factors in brood development and brood survival. While the data derived from such a small number of trees are not conclusive it would seem to be sufficient to offer a basis for speculation and for suggestion as to future investigation.

When we compare the data for the north quadrants of the two trees we obtain an excellent basis for judgment as to whether the data for the other three quadrants are of any value. The north quarter of the bark surface would at no time of the day be subject to direct sunlight, nor would it at any time be affected so strongly by the drying action of a wind from the south or southwest. We might be justified then in expecting the north quadrants of the two trees to show nearly the same number of attacks and about the same number of brood per square foot. This expectation is fully realized, for the smaller more exposed tree showed 4.3 attacks

while the larger more protected tree showed 4.32 attacks and 15.95 brood per square foot.

and 15.28 brood per square foot,/ These differences are so small as to be entirely negligible when dealing with anything so variable as are biological processes of this nature.

In the light brooded tree the north quadrant shows the heaviest brood of any of the four quarters of the tree, while in the heavy brooded tree it shows the lightest brood. Yet the average broods per square foot for the north quadrants of the two trees are practically identical. We would seem to be justified in concluding from this and from general observations that in a tree which presents optimum conditions for brood development the lightest brood would be in the north quarter of the bark; but if the tree is exposed to sun and wind and becomes dried out, we are very likely - almost certain in fact - to find the heaviest brood in this north quadrant, due to the much greater mortality in the other sections of the bark.

A comparison of the brood in the two trees in the other three quarters shows much greater and more variable differences. Thus the brood in the west quadrants were respectively 14.89 as compared to 24.51; in the south quadrant 7.01 as compared to 23.75; and in the east quarter 4.45 as compared to 20.57.

These figures lend themselves to further speculation. Why is the difference in the number of the brood in the two trees smaller in the west quarter than in the south and east quarters? Apparently the answer to this is that in neither tree was the western quarter of the bark surface exposed to direct sunlight. The differences between the two then would theoretically represent

the killing of the brood due to the drying out of the bark by wind action as distinguished from sun-kill while the greater differences in the two trees in the other two quadrants would represent not only the killing effect of drying but also the heat kill or sun kill due to the direct action of the sun on one of the trees.

This may seem like basing too much in the way of conclusions on too little data - like mere speculation in other words. That is confessedly just what it is - speculation. But the data seem to point so unmistakably to these deductions and to dovetail so perfectly with general conclusions - or general impressions - obtained from general and casual observations, as to make these impressions all the stronger. The subject would at least seem worthy of further investigation.

Experiments to Determine the Effect on Brood Development of Various Methods of Treating Trees Infested by Dendroctonus ponderosae.

The first series of these experiments were initiated September 2 and 3, 1924, by Dr. Craighead, Mr. Edmonston and Mr. Hofer. All of the trees treated are on the ridge east of Mile and a Half Park and about one mile southeast of Mile and a Half Lake. All except a few of the "E" treatments are on or near the top of the ridge. A few "E" trees are on the west slope of the ridge some 150 yards from the two main groups.

Series "A" Experiments of September 1924

Eleven infested trees were girdled by hacking a groove into the sapwood about 2-3 inches deep.

A-1. Tree 15" D.B.H. Bark corky, rather thin.
Felled and examined July 7, 1925.
Bark very tight, wood dry, much blue stain.
Brood irregular in distribution, little or none in some places; heavy brood in other places, mortality apparently early; white fungus - early. Considerable Cerambycid work in places - later. As compared with untreated trees brood was as good or slightly better.

A-2. Tree 11" D.B.H. Bark corky, medium thick, rapidly growing tree.
Felled and examined July 7.
Bark very tight, wood dry, much blue stain
Good brood had hatched and extended larval mines 1 1/2 - 2 inches, very few surviving brood. Brood slightly poorer than untreated trees.

A-3. Tree 14" D.B.H.
Blown down during winter
July 7. Brood partly killed on top of log (sun kill). Strong brood on sides. Brood averages as good or better than untreated trees.

A-4. Tree 9" D.B.H. Bark corky, medium thick. Slow growing tree.
July 9. Bark moderately tight. Moderate bluing. Considerable survival of brood - nearly as much as in untreated tree.

A-5. Tree 9" D.B.H. Bark corky, medium thick.
July 9. Brood nearly normal.

A-6. Tree 10" D.B.H. Medium bark, corky.
Blown down during winter.
July 7. Sapwood dry, no bluing. Very healthy brood - much more than in untreated tree.

A-7. Tree 9" D.B.H. Corky bark, medium thick.
Blown down during winter.
July 7. Strong brood - more than in standing tree..

A-8. Tree 14" D.B.H. Crooked. Bark corky; medium thickness; fairly good recent growth. Fairly heavy top but one-sided.
July 9. Considerable brood near butt of tree, very little above.

A-9. Tree 20" D.B.H. Bark very thick, scrubby tree.
July 9. Bark loose. Considerable Cerambycid work but good brood in places.

A-10. Tree 16" D.B.H. Bark thick.
July 7. Bark moderately tight, slightly moist. Considerable brood on north side, little brood on south side except in a few places.

A-11. Tree 14" D.B.H. Bark corky, medium. Top rather heavy, good growth.
July 9. Bark very tight, considerable bluing. Brood numerous below, considerable mortality above 10 feet.

Series "A" Experiments of June 1925.

This series of experiments was duplicated on the ridge west of Mile and a Half Park about 1/2 mile southwest of Mile and a Half Lake, the trees being treated June 2 and 3, 1925. Trees were girdled 2-3 inches deep into the sapwood.

Several trees of this treatment examined July 9, 1925, showed the bark rather tight and dry. Brood as numerous or rather more numerous than in untreated trees.

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Conclusions from the Series A Experiments of infested trees hack girdled early in September 1924 and early in June 1925 are that the treatment has little effect upon the condition of the brood. The brood in both treatments were examined July 7 and 9 and showed the numbers surviving at that time slightly in excess of those surviving in untreated trees. This treatment under climatic conditions of this year was of little effect either as a control measure or as a means of fostering an epidemic.

Series "B" Experiments of September 1924.

Nine infested trees were cut in such a manner as to lodge them in other trees at varying angles but all free of the ground.

B-1. Tree 14" D.B.H. Bark thin, corky; top medium.
July 9. Felled and examined. Bark very tight and dry, thin. Brood very scanty.

B-2. Tree 10" D.B.H. Bark thin, flaky. Top light
July 9. Felled and examined. Bark dry and very tight. Scarcely any brood.

B-3. Tree 19" D.B.H. Bark medium thick, corky; top heavy; growth rather slow.
July 9. Felled and examined. Bark medium tight. Brood numerous, many adults, larvae and pupae few.

B-4. Tree 20" D.B.H. Bark thick.
Tree blown down during winter.
July 7. Inner bark dry, no fungus or fermentation. Some kill of brood, but brood nearly average for untreated trees.
July 30. Average of 6 sq. ft. - 2 on each of 3 ten ft. logs - 14.9 beetles.

B-5. Tree 16" D.B.H. Bark flaky.
Tree blown down during winter.
July 7. Bark tight and dry, no moulds or fermentation. Considerable of brood killed. Some remaining in larval, pupal and adult stages.

B-6. Tree 18" D.B.H. Bark medium thin. Top rather light.
July 9. Moderately heavy brood near butt and about 10 ft. up.

B-7. Tree 13" D.B.H. Bark medium thick, corky. Top medium; growth slow.
July 9. Bark moderately moist. Brood poor (slightly below average) on south and east sides. Good brood on north side.

B-8. Tree 8" D.B.H. Tree not infested when felled - mistake.
July 9. Bark very wet. Nothing but Ips.

Series "B" Experiments of June 1925.

On June 3 eight trees were cut and lodged in other trees - duplicating the treatment of September 1924. These trees are on the ridge west of Mile and a Half Park.

July 9. Examination of several of the lodged trees showed the condition of the brood about normal - possibly slightly better.

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Conclusions from the Series B Experiments

In analysing the rather indefinite data recorded for these two experiments the only conclusion to be drawn is that the treatment had little effect upon the brood of Dendroctonus. In thin barked trees there was a poor survival of brood just as is usual in similar trees which had not been treated.

This treatment under climatic conditions existing this year had little effect either in reducing or building up the brood.

Series "C" Experiments of September 1924

Ten trees varying in diameter from 8" to 26" were felled September 2, 1924, the infested length cut out, and laid tight on the ground.

C-1. Tree 26" D.B.H. Bark rather thick
June 25. Tree examined to determine brood.
Bark rather thick
Several sample sq. ft. taken 27 ft. from stump as below.

K-56a. Upper surface.
Bark moist. Some white fungus.
Brood - 3 young adults per sq. ft.

K-56b. East side
Bark drier, considerable white fungus
Brood - 4 young adults per sq. ft.

K-56c. West side
Bark quite wet. Much white fungus
Brood - 1 young adult.

July 7. Bark on upper side moderately dry, on sides and bottom moist to quite wet. Much white fungus.
Brood - some alive on upper side. very few on sides and bottom.

C-2. Tree 20" D.B.H. Bark medium thick, rather scaly.
Felled N. and S. Part shade. Growth - 9 rings to last half inch.
Sapwood 6 1/2 inches.
June 23, 1925. Sample square feet taken 4' and 27' from stump.
Samples 4 ft. from stump.

K-55a. Upper surface
Adults 17
Brood - Pupae 2
19 per sq. ft.

K-55b. East side
Brood - 1 adult - Bark very wet
Poor infestation

K-55c. West side
Brood - 4 adults - Bark very wet
Poor infestation.

Sample sq. ft. taken 27 ft. from stump

K-55d. Upper surface

	Adults	22	(All undersized
Brood -	Pupae	2	(Some white fungus
	Larvae	2	
		26	per sq. ft.

K-55e. West side

	Adults	14	(Rather wet
Brood -	Pupa	1	(Considerable white fungus
		15	per sq. ft.

K-55f. East side

	Adults	5	(Rather wet
Brood -	Pupa	1	(Considerable white fungus
	Larva	1	
		7	per sq. ft.

July 7. Bark loose, moist, much white fungus in places.
Considerable kill apparent, but many still alive
Some kill by Cerambycids.
July 30. Bark very dry
4 sq. ft. 1st 10 ft. log - 0) Many dead adults
4 " " 2nd 10 " " - 7)
5 " " 3rd 10 " " - 0)

C-3. Tree 9" D.B.H. Bark medium.
July 7. Wet kill effective.
Brood very scanty.

C-4. Tree 13" D.B.H. Bark rather thin, scaly.
July 7. Bark reduced to frass by Ips
Brood - very few larvae and pupae alive.

C-5. Tree 19" D.B.H.
July 7. Rather dry. Some white fungus.
Fair kill. Some adults in places.

C-6. Tree 20" D.B.H.
June 10, 1925 - K-36.
8 ft. from stump
Several sq. ft. yielded

Adults (old)	13
Larvae	3
Pupa	1
	4 brood in several sq. ft.

Little sun kill. Considerable wet kill on under side.

C-7. Tree 8" D.B.H. Bark medium thick. Top light. Slow growth.
July 9. Bark green in places, very moist.
Good brood in butt.

C-8. Not examined.

C-9. Tree 18" D.B.H. Bark moderately thick, flaky.
Rather rapid growth.
June 1, 1925. - K-32. 20 ft. from stump
Some white fungus beneath
Larvae 15
Brood - Pupae 17
32 in little more three sq. ft. - about 10 per sq. ft.
July 9. Bark quite moist, loose.
Considerable brood - on under side near butt.
" " - on top and sides above 10 ft.
Heavy " - above 20 ft.

C-10. Tree 14" D.B.H. Bark medium thin.
Growth fairly good
Full sunlight from 10-12 A.M.
July 9. Bark wet, loose.
Brood - light on top.
Very heavy on sides and beneath except where close to ground.

"C" Treatments of June 1925.

Eight trees were felled June 2, 1925, the infested length cut out and laid flat on ground. In four of these the limbs were left on (by reason of misunderstanding of directions) and in the other four the limbs were all removed from the infested portion.

C-1. Not limbed. Bark medium thick. Top fairly heavy, moderate growth. Tree 20" D.B.H.
July 9. Bark moist, fairly loose.
Brood irregular, scattered, a little less than in untreated trees.

C-2. Not limbed. Bark thick. Top fairly heavy, moderate growth.
Tree 15" D.B.H.
July 9. Bark rather dry, tight.
Heavy brood survival.
Considerably better than in untreated trees.

C-3. Not limbed. Bark medium thick. Heavy top.
Tree 20" D.B.H. Fairly good growth.
July 9. Bark fairly moist, fairly loose.
Good heavy brood except where destroyed by Acanthocinus.

C-4. Not limbed. Tree 15" D.B.H. Bark scaly, rather thin; top medium light; fairly good growth.
July 9. Brood heavy on north side and underneath.
Sun kill on top.

C-7. Tree 17" D.B.H. Bark rather thin. Good top. Fair growth.
Not limbed.
July 9. Brood not heavy
High mortality.

C-5. Bark medium thick. Slow growth.
Limbed.
July 9. Bark moist, loose.
Heavy brood.

C-6. Limbed. Bark thick. Good top. Good growth.
Bark dry, moderately loose.
July 9. Heavy brood underneath.

C-8. Tree 11" D.B.H. Limbed. Bark thick. Poor top.
Slow growth.
July 9. Bark moderately moist, loose.
Heavy brood underneath.

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Conclusions from the "C" Treatments of Sept. 2, 1924, and June 2, 1925.

The data taken indicate that the trees which were felled June 2, 1925, the infested length cut out and laid next to the ground showed at the time of examination (July 9, 1925) brood which was on the average slightly better than that in standing untreated trees. The leaving on of the few limbs which occurred within the infested length had no apparent effect. In some cases in this June treatment there was a good kill (by sun kill) in the upper and south surfaces of the bark, but in all cases the brood was at least normally heavy on the north side and underneath.

It would appear that the increased moisture retained in the bark on the under surface and on the north side protected from the sun decreased the mortality in these regions to such an extent as to slightly more than

compensate for the sun kill on the upper surface, thus producing an average brood slightly in excess of that in untreated trees. Perhaps the most important factor in fostering the brood in this treatment was due to the greater protection of the felled trees from the drying effects of the heavy winds of May and June.

The series "C" experiments of September, 1924, give somewhat different results. In this experiment the infested length was cut out, trimmed and laid tight on the ground on September 2, 1924. Several preliminary examinations were made during June 1925 to determine the condition of the host and the progress of the brood. Several square feet of bark were removed from different trees of this treatment June 1, 10, 23 and 25. In practically every case the inner bark was found to vary from moist to very wet even though the condition of the soil was becoming quite dry by about June 15 and continued so until June 29. Also the presence of some or much "white fungus" was recorded in every case.

The number of brood found in these different examinations varied considerably. On June 1st in one log examined (C-9) the average per sq. ft. was about 10 larvae and pupae. This same tree showed "heavy" brood in the same region when examined July 9. The tree C-6 when examined June 10 showed only four living larvae and pupae in "several" square feet. Apparently this tree escaped examination July 7. An examination of 6 square feet in two regions of C-2 on

June 23 gave an average of 8 per square foot 4 feet from the stump and an average of 16 per square foot 27 feet from stump - or an average of 12 per square foot for the two regions. The examination of July 7 records "considerable kill but many still alive". An examination of C-1 on June 25 yielded an average of 2 2/3 per sq. ft.

From this data it is apparent that much of the mortality of the brood occurred before June 1st and this is borne out by an examination of the inner bark which showed a heavy kill of the larvae at about the time they reached half growth. This would mean either the late fall or the early spring. At the time of the examination July 7 it was the general opinion that the larval mortality was due to a very wet condition of the inner bark and a "souring of the sap". The white fungus present being an indicator of this condition. This is given credance by the wet or very wet condition of the inner bark at the time of the early summer examination. It is my own opinion that the very wet condition was probably brought about by the gradual melting in the spring of the snow covering the logs - allowing the bark and wood to become saturated with water. This probably resulted in the death of the brood either directly by drowning or favored a soured condition of the sap which killed the brood.

As to the efficiency of this treatment as a control measure I should not place the reduction in brood as more than 50% as compared with standing untreated trees. It is to be regretted that actual counts were not made of trees treated in this manner, but if I can interpret our rather general notes correctly - taking into consideration

our conception of "maximum average brood" at that time - I should place the efficiency of this method at about 50%. The data from the more extensive Dry Park Treatments which I had not examined until the above was written seem to bear out this opinion or to indicate that it is a trifle too optimistic. That data seem to indicate that the average sq. ft. for this treatment yielded about 3 brood while the average for standing trees at Dry Park was only 3.07 and for the entire forest was less than twice that number.

It is my opinion that had the early summer been wetter there would have been a higher mortality of brood in this treatment and coincidently a considerably lessened mortality in the untreated trees, thus bringing about a higher percentage of efficiency in the treatment. However, this is conjecture rather than a conclusion and while to my view the general evidence seems to point that way, specific citable data is lacking.

Another point which should be borne in mind in judging this treatment as compared with others is that it does not involve the destruction of certain natural enemies such as clerids and cerambycid larvae all of which are destroyed by either the burning or barking methods. The cerambycids especially seem to be a very valuable natural check and in so far as is possible control measures should attempt to foster rather than to destroy them. On the other hand the "C" treatment practically obviates or at least very much reduces any aid from another natural enemy of the beetle larvae - namely the woodpeckers. While the treatment would not result to their detriment as they would find plenty of food in standing trees, it would practically do away with whatever assistance they might render.

Series "D" Experiments of September 3, 1924.

Twelve trees varying in diameter from 7" to 24" were cut September 3, 1924, the infested length cut out and covered with branches.

D-1. Tree 24" D.B.H. Bark thick, corky; moderately good growth.
July 9. Bark very wet, very loose. Heavy infestation.
Poor survival on butt region; about 5% brood midway;
20 ft. up and above - 30-40% survival.

D-2. Tree 22" D.B.H. Bark medium thick. Fair growth.
June 1, 1925. - K-20-
1 sq. ft. - Northwest side - 10 ft. from stump.
Larvae - 76 - of which 54 were half grown or larger
pupa - 1
adults - 0
77 brood in 1 sq. ft. N.W. side.

K - 21

1 sq.ft. - Southeast side - 10 ft. up.
larvae - 72 - of which 50 half grown or more
pupae - 4
adults - 0
76 - brood in 1 sq. ft. S.E. side

July 9. Considerable cerambycid work - effective where present. Where cerambycid work did not occur the brood varied from fairly good to heavy.
(Photo. taken by Dr. Kraus to compare conditions June 1 and July 9).

D-3. Tree 13" D.B.H. Bark medium thick
July 9. Bark moist
Many cerambycids (Acanthocinus)
Good kill of brood.

D-4. Tree 12" D.B.H. Rather slow growth.
Many cerambycid larvae.
July 9. Brood numerous on underside - but retarded - mostly larvae and pupae. Larvae sickly.
Considerable brood elsewhere.

D-5. Tree 19" D.B.H. Bark thick, corky. Sapwood 6 1/2 in.
Growth 8 rings in last half inch.
June 23. 38 ft. from stump.
K-57a. Upper side - 1 sq. ft.
Quite wet, no fungus, considerable cerambycid work.
2 cerambycid larvae in the square ft.
Brood - adults 3 (cerambycid kill)
K-57b. East side - 1 sq. ft.
Very wet. No fungus - 2 cerambycid larvae.
Brood - adults 12, pupa 1 - 13 per sq. ft.

K-57c. West side, 1 sq. ft.
Very wet. Much cerambycid work.
Brood - adult 1, pupa 1, larva 1 - 3 per sq.ft.

July 30 - Bark wet. 75% inner bark destroyed by cerambycids.
Brood - 1st log 7 sq. ft. - no brood
2nd " 7 " " - " "
3rd " 18 " " - 32 "
4th " 3 " " - 13 "
Average brood 1 2/7 per sq. ft.

D-6. Tree 17" D.B.H. Bark thin, corky. Sapwood 3 1/2".
Growth - 32 rings in last half inch.
July 30 - Bark moist - cerambycid work 10-15%
Brood - 1st log 5 sq. ft. - 108
2nd " 4 " " - 572 - - Average of 4 sq.ft. -143
3rd " 4 " " - 33 per sq. ft.
713
Average brood per sq. ft. 50.9

D-7. Tree 17" D.B.H. Bark medium, corky. Sapwood 6 1/2"
Growth - 14 rings in last half inch.
July 13 - Bark moist - no cerambycid work.
Brood - 1st log 10 sq. ft. - 22
2nd " 3 " " - 81
3rd " 5 " " -165
4th " 11 " " -775
1043
Average brood for tree 36.1 beetles per sq. ft.
(Maximum broods of 107, 108 and 111 per sq. ft. recorded for this tree.)
August 26 - Examination of bark showed a few adults not yet emerged - on under side. Heavy mortality on upper side after brush was removed- dead young adults and pupae. There had been heavy emergence.

D-8. Tree 18" D.B.H. Bark thick - corky. Growth rather slow.
July 9. Bark wet, loose.
Heavy brood on under side and above 30ft.
High mortality on upper side in 1st 30 ft.

D-9. Tree 16" D.B.H.
No specific data.

D-10. Tree 13" D.B.H. Bark medium thick, corky. Sapwood 5".
Growth 25 rings to last half inch.
June 23. 15 ft. above stump
K-58a. Upper side - 1 sq. ft.
Considerable white fungus
Brood - adults 2
pupae 2
4 per sq. ft.

K-58b. East side - 1 sq. ft.
Wet, considerable white fungus.
Brood - larva - 1 per sq. ft.

K-58c. West side
Wet. Not much white fungus
Brood - adults 4
pupae 11
larvae 2
17 per sq. ft.
July 9 - Bark not excessively wet - about optimum.
Brood heavy.
July 13 - Bark moist, very little cerambycid work.
Brood - 1st log - 2 2/3 sq. ft. - 13
2nd " - 5 " " - 15
3rd " - 9 " " -108
Average brood per sq. ft. 8.2 brood

D-11. Tree 9" D.B.H. Bark thick, corky.
Poor attack - no brood

D-12. Not found.

In addition the bark was peeled from several regions in several trees of this treatment to determine the average brood. No records of the trees examined were kept - merely the figures recorded as follows:

1st tree - 55, 50, 52, 30 per sq. ft.
2nd tree - 40, 19 per sq. ft.
3rd tree - 20, 38, 21, 66, 31, 22, 42, 33, 33, 34, 58, 8, 36 per sq. ft.

average brood per sq. ft. for these three trees - 31.3

Series "D" Experimental Treatments of June, 1925.

Eight trees were felled June 2 and 3, 1925, the infested length cut out and covered with brush - duplicating in spring treatment the "D" treatments of September, 1924.

D-1. Tree Bark rather thin, corky.
July 9. Bark moist, loose; top heavy, growth fair.
Many cerambycid larvae - efficient work.
Brood of Dendroctonus - scanty.

D-2. Tree 13' D.B.H. Bark medium, corky. Sapwood 4 1/2"
Growth - 18 rings in last half inch. Infested length 20'.
July 31. Bark very dry, tight. No Cerambycid work.
20% woodpecker work.
Brood - 1st log - 3 sq ft. - 27
2nd " - 6 " " - 6
33
Average brood per sq. ft. 3.66

D-3. Tree 17" D.B.H. Bark thick, corky. Sapwood 5 1/2".
Growth - 18 rings in last half inch
July 31. Bark medium dry, med. tight.
Cerambycid work - 20%
Woodpecker " - 20%
Brood - 1st log - 3 sq. ft. - 6
2nd " - 5 " " - 3
9
Average brood per sq. ft. 0.9

D-4. Tree Bark thick, corky. Top good, growth slow.
July 9. Bark wet, loose.
Brood heavy in butt.
Dry kill above butt log.

D-5. Not found and hence not examined.

D-6. Tree Bark scaly - growth slow.
July 9. Bark rather dry and tight.
Much Ips in butt.
Some survival of Dendroctonus.

D-7. Tree 20" D.B.H. Bark medium thin and corky; sapwood 3 1/2". Growth 19 rings in last half inch. Infested length 36ft.

July 31. Bark medium dry, medium tight.

Cerambycid work 5%

Woodpecker work 5%

Brood - 1st log - 5 sq. ft. - 50
2nd " - 5 " " - 35
3rd " - 4 " " - 24
4th " - 3 " " - 4
113

Average brood per sq. ft. - 6.64

D-8. Tree D.B.H. Bark medium thin. Growth fairly good.
July 8. Brood fairly good - probably better than in untreated trees. Retarded - larvae, pupae and adults.

Conclusions from the "D" Treatments of September 1924 and June 1925.

The data at hand indicate that the treatment of June 2 and 3 had little effect upon the brood. Specific data were taken of three trees which seem to be representative of this treatment and in these trees the average brood was 4.3 per square foot. This is not far from the average of brood for the untreated trees of the entire forest. The general observations recorded for the other trees of this treatment contain nothing which would lead to any other conclusion.

It is believed that the differences between the effect upon the brood by the "D" treatments of June and September are due nearly entirely to the greater drying out of the June trees. There is another factor concerned - that of woodpecker work which of course is entirely absent from the September trees - but its efficiency in no way accounts for the very striking differences in the amount of brood.

The results obtained by the "D" treatments of September 2, 1924, were entirely different. In trees of this treatment brood was heaviest both as to maximum brood per square foot, as to average brood per tree, and as to average brood of all trees treated in this manner. Maximum broods of 107, 102, 111, per square foot were obtained from "D-7" and an average from 4 sq. ft. of 143 from "D-6". An average brood of 36.1 and 50.9 per square foot was recorded for these same trees. An average of 31.3 brood per square foot was obtained from three trees (numbers of trees not recorded). A total average of 21.13 brood per square foot was obtained from all of the numerical data of this treatment based on a total of 98 square feet of bark surface. This shows an average brood about four times as heavy as the average for the untreated trees of the forest.

It was very noticeable that the brood was considerably retarded in these shaded logs - so much so that at the time when the young beetles were actively emerging from untreated trees (July 30) much of the brood in the shaded trees was in the pupal and even the larval stage. This without doubt is due to the lower temperature due to shading by the covering branches. Note also that an examination of "D-7" on August 26 showed a few adults still present although this log had been uncovered since July 13.

The inner bark of the logs of this treatment whenever examined (from June 1 to July 30) showed the condition of the inner bark to vary from moist to very wet with the average condition wet. There was little white fungus as compared to logs of the "C" treatment. This difference was probably due to the lower temperature in the shaded logs which even in

the presence of sufficient moisture was not high enough to induce the "souring of the sap" and the development of the white fungus.

Some of the logs showed considerable work by Cerambycid larvae, others very little and still others none at all. The data for "D-2" is interesting in this connection as this log showed very heavy brood - (average of 75 1/2 per square foot) on June 1. This was followed by effective cerambycid work which showed up at time of examination July 9. Note that where cerambycid work was not present in this log - the "brood varied from fairly good to heavy".

In conclusion - this treatment under climatic conditions as they existed this year was worse than useless as a control measure as it had the effect of fostering the brood rather than destroying it. However, it is possible that if the season had been wetter, or had had greater than normal rainfall, the conditions under the bark would have been much wetter than the optimum and might have resulted in a "wet kill" of the brood.

Series "E" Experiments of September 2, 1924.

Ten trees varying in diameter from 11" to 28" were cut in groups and the tops thrown together in such a manner that most of the trunks were free of the ground. The limbs were not cut.

E-1. Tree 28" D.B.H. Crown heavy. Bark thick, corky. Sapwood 9"; increment last half inch - 18 years.

July 7. No sun kill.
Heavy brood on upper side and sides.
Heavy kill by Acanthocinus larvae

July 30. Bark moist, tight. 80% kill by cerambycids.

Brood -	1st log -	4	sq.ft.	60 brood
	2nd " -	6	" "	0 "
	3rd " -	4	" "	4 "
	4th " -	2	" "	6 "
	Tree	16	" "	70 "

Average brood - 4.3 per sq. ft.

E-2. Tree 24" D.B.H. Crown heavy. Bark medium thick, corky; Sapwood 8"; increment last half inch - 8 years

June 23, 1925.

K-60a. 33 ft. from base. Bark tight and dry.
1 sq. ft. on upper side

Adults	22	
Pupae	18	part sickly
Larvae	16	most sickly
	56	in 1 sq. ft.

Shaded except for a short time about noon.

K-60b. Not so dry, bark tight.
1 sq. ft. East side of log.

Brood - Adults	34	
Pupae	36	
Larvae	8	
	78	in 1 sq. ft.

K-60c. Bark tight.
1 sq. ft. East side

Brood - Adults	3	
Pupae	29	
Larvae	19	
	51	in 1 sq. ft.

July 30, 1925. Bark slightly moist, rather tight.
Sun kill on top - 10% by Cerambycids
Brood - 1st. log 4 ft. 44 brood
2nd " 2 " 16 "
3rd " 3 " 3 "
9 " 63 "
Average brood - 7 per sq. ft.

K-3. Tree 30" D.B.H. Top heavy. Bark medium, corky.
Sapwood 7"; increment 17
June 23, 1925.
Strong infestation. Sunny site.
K-59a. Upper side of log.
No live brood - bark very dry and tight.

K-59b. N.E.side of log. Bark loose, fairly moist
Brood healthy.
Adults 21
Pupae 9
Larvae 1
31 per sq. ft.

K-59c. S.W.side of log. Bark dry and tight.
Adults 1
Pupae 2
Larvae 4
7 per sq. ft.

K-59d. Under side of log. Bark loose, not very dry.
Adult 1
Pupae 15
Larvae 6
22 per sq. ft.

July 7. Kill efficient on upper side.
Heavy brood on sides and underneath

July 30, 1925. Bark dry and tight
15% kill by Cerambycids
Sun kill on top and South side
Brood - 1st. log 4 sq. ft. 56 brood
2nd " 2 " " 0
3rd " 1 " " 12
4th " 3 " " 24
92
Average brood per sq. ft. - 10.2

K-4. Tree 20" D.B.H. Bark medium, corky; crown heavy;
Sapwood 7"; increment 14.
Felled East, shaded from 11:00 A.M. to 2:00 P.M.
July 15, 1925.
3rd log upper side - 10 per sq. ft. - but all dead
" " under " 89 " " " - all alive
" " sides 12 " " " " "
1st " upper half 28 " " " " "

July 30, 1925. Bark dry on top, tight.
20% Cerambycid kill. Sun kill on top.
Brood - 1st log 4 sq. ft. 86 brood
2nd " 3 " " 4 "
3rd " 2 " " 14 "
9 110
Average - 12.2 per sq. ft.

K-5. Tree 13" D.B.H. Bark medium, corky; crown medium;
Sapwood 4"; increment 18.
May 30, 1925.
K-16. North side of trunk. 18 ft. from stump.
Brood - Larvae 57
Pupae 0
Old adults 4
Of the 57 larvae, 49 were half grown or less, 7 in last instar, 1 prepupa. Some of larvae doubtless from eggs laid this spring from overwintered adults.

K-17. Upper south side of trunk. 18 ft. from stump.
Brood - Larvae 41 of which 34 were half grown or less.
Pupae 0
Old adults 5
Upper south third of log showed 100% sun kill
Bark very dry.

July 30, 1925. Bark moist, loose.
No Cerambycid kill
Brood - 1st log 2 sq. ft. 26 brood
2nd " 2 " " 10 "
3rd " 1 " " 3 "
5 39
Average brood 7.8 per sq. ft.

E-6. Tree 16" D.B.H. Bark medium, corky; crown medium;
Sapwood 5"; increment 16.
July 9, 1925. Good brood.
July 30, 1925. Bark tight and dry above, moist below.

Brood - 1st. log	2	sq. ft.	20	brood
2nd "	3	" "	6	"
3rd "	2	" "	4	"
	7		30	

Average brood per sq. ft. 4.3
Sun kill on top.

E-7. Tree 14" D.B.H. Bark thin, corky; Crown medium.
Sapwood 4"; increment 19.
July 30.

Brood - 1st log	3	sq. ft.	8	
2nd "	3	" "	21	
3rd "	3	" "	21	
	9		51	

Average brood per sq. ft. 5.6
Sun kill on top and south side

E-8. Tree 12" D.B.H. Bark thin, and corky; crown medium
Sapwood 4"; increment 36.
July 9, 1925. Full brood.
July 30, 1925. Bark tight and dry on top, looser below.

Brood - 1st log	2	sq. ft.	10	brood
2nd "	2	sq. ft.	4	"
			14	

Average brood per sq. ft. 3.5
Sun kill on top.

E-9 and E-10. No brood of Dendroctonus
All Ips.

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The Series "E" treatments shows several interesting points. -

Trees felled without limbing and for the most part free of the ground showed an average brood - based on sixty nine square feet taken from eight trees - of 6.8 beetles per square foot. These counts were made on July 30 when some emergence had already occurred and when practically all pre-emergence mortality had presumably occurred. The average

brood in standing trees on this same ridge, taken 10 days previously and based on 19 trees examined, was 6.172 beetles per sq. ft. Thus the treated trees showed a slightly higher average brood. This was in spite of the fact that in nearly all of the trees there was a nearly 100% sun kill of the brood on the upper side of the trunk above the first 10 ft. log. Effective kill usually involved from 1/4 to 1/3 of the circumference of the log.

In one or two trees sun kill was not effective because the log was in such a position as to be shaded during the day except for a short time. Also sun kill was not usually at all effective on the butt-log of the tree. This is probably due to the greater amount of moisture in this part of the tree and more still to the thicker bark. The average brood for the first logs of the eight trees was 12.5 beetles per sq.ft. while that for the remaining logs of the eight trees was 3.6 per sq. ft. From this it is evident that the mortality in the upper logs was not all due to sun kill but that considerable mortality also occurred in other portions of the bark besides that exposed to the sun's action. This is doubtless due to the greater drying out of the thinner barked upper logs. The lowermost log too is farther removed from the limbs, twigs and leaves through which much of the evaporation must take place.

In spite of the sun kill the trees of this treatment show a slightly higher brood than standing trees of the same site and locality. If we assume that the sun kill amounted to 1/5 of the brood which would otherwise occur then this treatment would show an average brood

of 8.16 or about 2 beetles per square foot more than in standing untreated trees. To what is this due? I believe it is due largely to the lessened effect of the wind in drying out the tree. The trees were near the top of the ridge but below the apex on an east slope. The winds which were continuous and heavy during all of June were from the south and southwest. Thus the trees were somewhat protected not only by the mere act of felling but by the apex of the ridge which acted as a partial wind break. Had they been farther down the slope I believe they would have shown considerably higher brood counts. (Note in this connection that counts of brood in standing trees on east slopes showed more than double the brood of nearby trees in localities more exposed to wind action.)

Wind action would also have the effect of decreasing the efficiency of sun kill. Sun kill is apparently largely if not entirely due to the raising of the subcortical temperature. (Although moisture conditions in conjunction with temperature must be of some effect but just how and to what extent we do not know.) The action of wind upon the surface of the bark would have a cooling effect similar to currents of air passing over an automobile raditor, i.e. it would tend to keep down the temperature. The constant strong winds of this June were doubtless responsible for the failure of the sun-curing method of control on the Kaibab forest this year.

In conclusion.- The Series "E" treatments were not successful as a means of control under conditions as they existed this year. It is not believed that they offer much promise of success in normal years.

Trap Tree Experiments in the Kaibab National Forest in 1925

These trap tree experiments were outlined by Dr. Craighead for the purpose of determining the effect of trap trees prepared in various ways and at different times in attracting D. ponderosae and to observe the effect on the subsequent development of the brood in such trees. The trees were treated in three different ways - (1) Belt girdled - by removing a strip of bark completely around the tree and two feet wide. (2) Hack girdled - by hacking a groove in the sapwood about three inches deep and completely encircling the tree. (3) Felling - by felling the tree and cutting off a sixteen foot butt-log from each, leaving the branches on the root.

It was directed that the first series of these trees should be prepared by Edmonston and Hofer about October 15, 1924, the experiments to be duplicated about May 1, 1925 and at intervals of one month during the summer. On account of a misunderstanding of the directions the October trap trees were not prepared, but sets of trap trees were laid down May 1 and each month up to September 1, 1925. Also at the time the Forest Service road was built at Dry Park during September and October of 1925 numerous trees were felled, limbed and left on the ground by the road side. These were examined twice during the summer and in a measure take the place of the traps omitted in October.

In summarizing the results from these trap-trees it seems to be advisable to consider the different treatments separately. We will consider the belt-girdled trees first.

Belt-Girdled Trap Trees

The first treatments were made April 30 and May 1, 1925, at Mile and A Half. Four trees were prepared - two on the ridge just east of camp and two on the ridge west of camp.

Tree B-a-1, 4/30/25 - 15" D.B.H.. At top of ridge in rather dense stand of yellow pine. The tree at no time during the summer showed any fading of the foliage or any other indication of loss of vitality.

June 15 — 1 attack by Dendroctonus valens below girdle
June 29 — 3 " " " " " "
July 6 — 5* " " " " " "

These burrows of D. valens were not disturbed, but should be examined in the early summer of 1926 to determine whether or not the brood is able to live through in living trees.

Tree B-a-2, 4/30/25 - 16" D.B.H., Near B-a-1, of even date and in similar surroundings.

No change in foliage - no attacks by insects.

Tree B-a-3, 5/1/25 - 17" D.B.H. At top of ridge west of camp. In rather open stand. S.W. exposure.

No indication of reduced vitality during summer.

June 8 — 1 attack by D. valens, below girdle, not very/ pitchy tube
July 28— 3 " " " " " "

* These numbers indicate total attacks to date and not new attacks.

On July 6 a small tree 10" D.B.H., 3 1/2 feet away was attacked by D. valens, 1 1/2 ft. from base. A second attack was observed July 15.

Tree B-a-4, 5/1/25 - 14" D.B.H. In dense stand at top of ridge.

No loss of vitality during summer.

No attacks by insects.

Tree B-a-1, 5/29/25 - 15" D.B.H. West slope of East Ridge one half mile northeast of camp. South and west exposure.

No indication of loss of vitality during summer.

June 29 -- 1 attack by D. valens?, below girdle
This was a failure as burrow was abandoned
July 15 -- 1 attack by D. ponderosae @ 12' up - north side
Not examined but certainly a failure, as attack was not followdd up by other beetles.

Tree B-a-2, 5/29/25 - 19" D.B.H. West slope near above but farther down slope - south and west exposure.

July 6 -- 1 attack by D. valens, below girdle - south side
July 15-- 3 " " " " " " - south and northwest sides

Tree B-a-3, 5/30/25 - 18" D.B.H. West of draw. 1 mile north of camp.

June 29 -- 5 attacks by D. valens - 4 pitch tubes
July 29 -- 7 " "

Tree B-a-4, 5/30/25 - 18" D.B.H.. Near above

No attacks up to August 21

Tree B-a-1, 6/29/25 - 16" D.B.H. West of Draw, 1/4 mile Northwest of camp. South slope, southeastern exposure.

July 15 — 3 attacks by D. valens, below girdle
July 28 — 4 " " " " " "

Tree B-a-2, 6/29/25 - 14" D.B.H. Near the above, but higher up on slope.

July 6 — 1 attack by D. valens, below girdle
July 15 — 3 " " " " " , nothing above
July 23 — 9 " " " and D. sp. " " "
July 29 — 15 " " D. ponderosae, above girdle — —
July 30 — 23 " " " " " "
July 31 — 42 " " " " " "
Aug. 1 — 63 " " " " — —
Aug. 3 — 76 " " " "
Aug. 4 — 101 " " " "
Aug. 7 — 148 " " " "
Aug. 10 — 186 " " " "

This tree was near one of the felled trees and in the center of one of the largest groups of newly infested trees (1825 attacks) in the vicinity of Mile and A Half. This tree was apparently completely filled in and killed by D. ponderosae.

Tree B-a-3, 6/29/25 - 15" D.B.H. East ridge just south of pasture fence. Numerous light-brooded trees south and east.

July 15 — 6 attacks by D. valens, below girdle
Aug. 3 — 10 " " " " " " ,nothing above.

Tree B-a-4, 6/29/25 - 18" D.B.H. Near the above.

July 15 — 3 attacks by D. valens, below girdle
Aug. 11 — 5 " " " " " "

Tree B-a-1, 7/29/25 - 13" D.B.H. East ridge, 150 ft. from nearest trap tree.

Aug. 10 — 1 attack by D. valens?, below girdle.

Tree B-a-2, 7/29/25 - West ridge

No attacks up to September 1, 1925.

Nothing of practical importance in the way of conclusions can be drawn from the above data. It seems certain that belt-girdled trees do not offer an especial attraction to attack by D. ponderosae. The only tree of this treatment which was attacked in numbers was one occurring in the center of an aggressive group of attacks and this tree, while it was eventually filled in by enough beetles to probably kill it, was not filled in as promptly as were other untreated trees adjacent to it. As a matter of fact the girdle covered with semi-hardened pitch acts mechanically in retarding the beetles in their work. During the early phases of the attack upon a tree many of the males and at least a few of the females lose their foothold on the bark and fall to the ground. They immediately try to ascend the same tree and are delayed and sometimes prevented from doing so by the broad band of pitch. They are perfectly able to make their way through fresh pitch but are always retarded by the semi-hardened material and not infrequently become "mired-down" and embedded in it. You will find more with regard to this in the notes on hack-girdled trees. It is also possible that the odor of the hardened or semi-hardened pitch has a repelling effect; but if so this cannot be a very strong repulsion except where the girdling has been done several months previously.

Whatever may be true as regards the attraction of the belt-girdled trees for D. ponderosae there can be little doubt that they do offer a strong attraction to D. valens. Of the fourteen trap trees thus prepared ten were attacked. Some of these attacks were unsuccessful while others examined several weeks after attack still contained the living parent adults. As observations made by Graham in Minnesota upon this species lead to the conclusion that D. valens cannot successfully pass through its life history in a living white pine tree, and as observations made in California indicate that in the western pines it is able to breed successfully, it was thought best not to disturb too many of the attacking beetles until the spring of 1926. At that time a thorough examination of these attacks should be made.

Aside from the two species of Dendroctonus no other beetles were observed attacking the belt-girdled trees - but of course no examination could be made, except of the lowermost few feet of the trunk. However, the trees seemed perfectly normal and attack by other Scolytids is not probable.

Hack-Girdled Trap Trees

Tree B-b-1, 4/30/25 - 16" D.B.H. near B-a-1 of even date.

No fading of foliage or other evidence of lost vitality during summer.

No insect attacks.

Tree B-b-2, 4/30/25.- 16" D.B.H. Near above.

Tree remained normal in appearance until blown over by the wind during first week in June. At this time the foliage was apparently normal, inner bark normal, lateral buds 1" long, terminal buds 2 1/8" long and no evidence of insect attack on trunk, limbs or twigs.

The later history was comparable to that of the felled trap trees put down the preceding week.

Insect attacks. The first insect attacks were 3 abortive burrows by Pityogenes carinulatus on June 15, in the smaller branches.

June 22 -- Light attack of Pityogenes carinulatus on limbs and of Pityophthorus sp. on the twigs. Light attack by Ips oregoni on upper trunk - none below 36' from stump.

June 29 -- Ips considerable on first 16', heavier above, very heavy above 30' from stump. D. valens on stump, No ambrosia beetles.

July 6 -- D. valens on trunk.

July 18 -- Attacks by D. approximatus and D. convexifrons on butt log.

July 29 -- Ambrosia beetles (Gnathotrichus retusus) clear to the butt. Hylurgops subcostulatus on stump and under side of butt log. D. valens - several attacks on stump.

Aug. 1 -- Larvae, pupae and young adults of Ips oregoni in second log. Also a few old parent adults of Ips.

Tree B-b-3, 5/1/25 - 18" D.B.H. West Ridge.

No evidence of weakening during summer.

No insect attacks during summer.

Tree B-b-4, 5/1/25 - 15" D.B.H. West Ridge.

No evidence of lessened vigor.

Insect attacks

June 15 -- 1 attack - D. valens - below girdle
June 22 -- 2 " " " " "
June 29 -- 5 " " " " "
July 15 -- 4 " " " " "
Aug. 3 -- 1 " D. ponderosae, " "

The August 3 attack by D. ponderosae was unsuccessful, the dead insect being found embedded in the pitch.

On August 25 an examination of D. valens burrows was made. All but one were abandoned. This contained a living adult male. No eggs or larvae found.

Tree B-b-1, 5/29/25 - 21" D.B.H. East Ridge near B-a-1 of even date.

June 29 -- 5 attacks - D. valens - below girdle.
July 6 -- 1 " - D. convexifrons - above girdle.
July 29 -- 3 " - D. approximatus - " "
(Small tree 5' away, 9 D.m.m., 5 attacks by D. ponderosae. Other attacks as follows - Aug. 1 - 9 times; Aug. 3 - 23 attacks; Aug. 4 - 37; Aug. 8 - 51; Aug. 10 - 67. Later killed.)
Aug. 10 -- 10 attacks - D. ponderosae - above girdle
Aug. 15 -- 20 " " " " "
Aug. 17 -- 36 " " " " and "below girdle
Aug. 21 -- Very many attacks "
Aug. 25 -- Nearly or entirely filled in. Nearly certain kill.

On August 26 a number of bark beetles were found embedded in the partly hardened pitch in the girdle of this tree. These

included 1 D. approximatus, 10 D. ponderosae, mostly males and several Hylurgops subcostulatus. On August 29 two more D. ponderosae and several H. subcostulatus were collected from the same girdle.

Tree B-b-2, 6/29/25,- 15" D.B.H. Near above.

July 6 — 1 attack - D. valens - below girdle.
July 15 — 3 " " " "
July 29 — 5 " " " "

Tree B-b-3, 6/30/25,- 20" D.B.H. West side of draw, about 1 mile north of camp.

June 29 — 5 attacks - D. valens - below girdle.
July 15 — 6 " " " "
July 29 — 7 " " " "

Tree B-b-4, 6/30/25, - 18" D.B.H. Near above.

June 29 — 2 attacks - D. valens - below girdle
July 29 — 3 " " " "
1 " D. ponderosae - possibly old.

Tree B-b-1, 6/29/25, - 19" D.B.H. West of draw, south slope.

July 15 — 3 attacks - D. valens - below girdle
July 28 — 5 " " " "
Aug. 3 — 7 " " " "

Tree B-b-2, 6/29/25, - 18" D.B.H. Near above but farther north up the slope.

July 6 — 1 attack - D. valens - below girdle
July 15 — 5 " " " "
July 28 — No change
July 29 — 8 attacks - D. ponderosae - above girdle
1 " " - below girdle
Aug. 3 - 11 " " - 2 " "
Aug. 7 - 15 " " --------
Aug. 10 - 50 " " --------
Aug. 14 -192 " "
Aug. 20 - Tree apparently filled in and killed.

It is interesting to note in connection with this trap tree that it was in the center of an aggressive new infestation. Between the date of first attack, July 29 and August 20 when it was listed as "filled in" with attacks, 27 other trees near by and in the same group were attacked and 14 completely filled in and pronounced as sure to die. This would seem to indicate some retarding of the attack upon the hack-girdled tree. In this connection it is interesting to note that August 26, 19 dead specimens of D. ponderosae, mostly males, were taken embedded in the partly hardened pitch of the girdle.

Tree B-b-3, 6/29/25 - 22" D.B.H. East ridge south of pasture.

July 15 -- 2 attacks - D. valens - below girdle
Aug. 3 -- 5 " " " "

Tree B-b-4, 6/29/25,- 22" D.B.H. Near last tree.

July 28 -- 6 attacks - D. valens - 5 below, 1 above girdle
Aug. 10 -- 9 " " " 8 " 1 " "

Tree B-b-1, 7/29/25,- 17" D.B.H. Limby tree with little clear trunk - 100 yards south of last tree. East ridge.

No insect attacks.

Tree B-b-2, 7/29/25,- 16" D.B.H. West side, south slope - near treatment of 6/29/25.

No insect attacks.

The conclusions to be drawn from the study of the hack-girdled trap trees are very similar to those for the belt-girdled trees. The hack-girdled trees certainly do seem to exert an attraction for D. valens. Of the fourteen trap trees, ten were attacked - exactly the same proportion as with the trees girdled in the other manner. It is worthy of note that the trees girdled July 29 were not attacked by D. valens in either case. This, however, is due to the fact that few if any beetles of this species are on the wing at that time - or at least such was the case this year. As regards the success or lack of success of the D. valens attacks definite conclusions cannot yet be drawn; but on August 25 an examination of the four attacks on trap tree B-b-4 of 5/1/25 was made. In three of these burrows no insect in any stage was found while in one burrow a living adult male was present. It would seem from this that at least the majority of attacks by D. valens on girdled trees are not successful. However, no real conclusions can be drawn until these attacks are all examined next summer.

As regards the efficiency of this sort of trap tree in inducing attacks by D. ponderosae, four hack-girdled trees showed attacks by this beetle. Of these, two trees suffered only a single attack, while the other two were apparently filled in heavily enough to insure the tree's death. Those attacked by only a single beetle can be ignored entirely, as a single attack would offer no evidence of any value. Of the two hack-girdled trees killed by heavy attacks, both were within a very few feet of felled trap trees. One was in

the center of a heavy new infestation and was one of the first trees (after the felled tree) in the group to show pitch tubes of the beetle. However, the beetles were much slower in filling in on this tree (compare with adjacent belt-girdled tree) than on other normal trees attacked at the same time or later. Between the date of first attack (July 29) and August 20 when it was finally listed as sure to die, 27 other trees in the same group infestation were attacked and 14 of these completely filled in and listed as sure to die.

The other hack-girdled tree killed by D. ponderosae was only a few feet from a felled trap tree. This felled tree was first filled in above the butt log by Ips, Pityogenes, etc. Then later the butt log was attacked by Ips integer, Ips Oregoni, D. approximatus, D. valens and finally in late July was filled in by D. ponderosae. On July 29 a small tree very close to both of the trap trees was attacked and filled in about August 10. On August 10 the hack-girdled trap tree was first attacked by D. ponderosae and by August 25 was listed as nearly certain to die.

In both these cases then the hack-girdled trees were killed, but in neither case did they seem to be more attractive to the beetle than normal trees. As a matter of fact in one case an adjacent tree was killed before the trap tree was attacked. In the other case, while the trap tree was attacked at the same time as nearby normal trees, it was not attacked by sufficient numbers to insure its death until fourteen untreated trees nearby, on many of which the initial attack had been later, had been killed. This would seem to indicate

the possibility of some retarding influence in the trap trees. At least part of this retarding influence, after initial attack, is due to the difficulties and dangers of the beetles in crossing the large quantity of partly hardened pitch in the girdle as shown by the considerable number of beetles mired down and killed in this sticky substance. In addition many others were noted which had succeeded in crossing the barrier of pitch but were so badly "gummed up" that they could hardly walk. These beetles retarded in crossing the pitch probably fall in two categories. (1) Beetles which in attempting to attack the tree failed to gain a foot-hold and fell to the ground, and (2) beetles principally males which had been thrown from the tree. This may require some explanation. In attacking, the beetles have been observed flying through the air and hovering near trees. When their choice of the tree to be attacked is made they dart toward that tree from a distance of several feet and often strike it with such force that the sound can be heard 8 or 10 feet away. Sometimes they obtain foothold at once and immediately begin seeking about in the bark-crevices for a point of attack, or if the attacking beetle is a male, seek for a burrow already started by a female. Often, however, they do not obtain a foothold on striking the tree but fall to the ground. In such case they usually climb up the tree. It is then they experience the difficulty with the sticky pitch. In the second category are the beetles, principally males which have lost their foothold on the tree or have been thrown off in their strivings for the females. Several instances were observed where beetles in attempting

to ascend the trees and experiencing difficulties in crossing the pitch, crawled back down below the girdle, smeared the adhering pitch upon the bark and flew away - presumably to some other tree.

Aside from the attacks by D. valens and D. ponderosae the only other insects attacking the hack-girdled trees were D. approximatus and D. convexifrons. These, however, were found on only one trap tree of this type and in all cases were unsuccessful. Their attacks were probably induced by the adjacent felled trap tree. This felled tree although filled in by the beetles still apparently offered an attraction and the surplus beetles attempted to breed in the standing trap tree.

FELLED TRAP-TREES

This treatment consisted in felling the green tree, cutting out the first 16 ft. log and leaving the limbs on the remainder. There remained above the cut out log from 10 to 30 feet practically free of limbs. Thus two conditions were produced - the butt log which dried out more slowly and the upper portion which on account of greater evaporation through the leaves and twigs, dried out more rapidly. Examinations of these trap trees were made at nearly regular weekly intervals and, whenever interesting developments were occurring, as during the height of attack by D. ponderosae, more frequent observations were made. Notes were taken not only on insects attacking the trap trees, but also an attempt was made to express the changes taking place in the leaves and in the bark at various regions of the tree. Perhaps this is the best place to summarize these very imperfect observations.

As regards the leaves.- The first change observable consists in a slight loss in the luster of the leaves which makes itself apparent about two or three weeks after the tree is felled. At this time also, if the leaves are drawn through between the fingers one can readily note an absence of the waxy feeling characteristic of the living foliage of western yellow pine. At this time also or shortly later a characteristic drooping of the tufts of foliage on the twigs is to be noted. This, however, is not due to a wilting of the foliage itself but to a drooping of the limber twigs under the weight of the foliage. The time at which fading

and drying out of the foliage occurs varies considerably and is perhaps correlated with the size of the crown, water conducting tissue and actual water content of the tree at the time of felling. In some trees the first signs of fading begin to appear in about four weeks after felling, while in others no signs of fading may be seen until a week or more later. Full fading of the foliage takes place in from two to two and a half months after cutting. When limbs are broken or lopped off in felling, fading of the foliage of course occurs much sooner.

As regards the bark.- As would be expected the first signs of change in the inner bark or phloem are found on the twigs and smaller branches. These first become streaked and later brown and tight. The promptness with which these changes appear varieswith the season, exposure to sun, and perhaps also with the crown and increment and the tree's sap-content at the time of felling. The twigs of the trees felled April 29 did not begin to show much discoloration of the phloem until early in June - about five weeks after felling. On the other hand the trees felled a month or two months later showed a streaking of the phloem in about 3 weeks and in two cases where they were fully exposed to the sun discoloration appeared in 16 days. Change in the phloem of the thicker barked portion of the tree is much slower. In sawed out butt logs there is little change in color at the end of ten months provided the log lies in a situation where the sun never strikes it directly and provided it is not attacked by insects.

The only color change consists in a slight deepening of the creamy tint of the inner bark, which at the same time gradually becomes less sappy and more sticky. However, very few logs remain unattacked by insects for this length of time. When the log lies in the sun the phloem becomes dry and brown after several weeks or months - the time varying with the character and thickness of the outer bark.

Insect attacks on the felled tran trees.

Tree B-c-1, 4/30/25 - 17" D.B.H. S. W. corner Bar Z pasture.

May 17 Ips oregoni. A few above first log.
May 22 " " A few on upper part of first log. More above.
May 24 " " Eggs laid. Adult clerids on bark.
May 25 " " Entire bole except first 8 ft. Clerids very numerous, copulating.
June 8 Ips oregoni. Scarcely any on first 8 ft; slight on second 8 ft.
Ips oregoni. Heaviest on third 16 ft. log and up. Fairly heavy on lower branches, little on upper branches.
Pityogenes carinulatus & Pityophthorus sp. on twigs and branches. Not heavy attack.
June 15 D. valens attacking stump
Ips oregoni & I. integer. A few on basal 8 ft. Many on second log. Larvae one-half grown or more.
H. subcostulatus on second log, under side.
June 22 Ips oregoni on second log and above; nearly full grown, not so advanced farther down.
D. valens. 6 attacks on stump.
June 29 Ips sp. Average attack on butt log. More above.
Gnathotrichus retusus. Considerable above butt log up to 54 ft. None on butt log.
H. subcostulatus. Considerable on second 8 ft. of butt log.
July 6 D. approximatus. Butt log, 9 ft. from stump - on sides of log eggs laid.
Ips oregoni. Old adults, larvae, pupae and young callow adults.
July 27 Gnathotrichus. All over butt log and stump.
Aug. 11 Ips oregoni. A few young adults still present but most have emerged.

Tree B-c-2, 4/30/25 - 15" D.B.H. S. W. corner Bar Z pasture.

May 18 Ips oregoni. Second log and up. Not many.
May 24 " " A few on second 8 ft. of first log.
Adult Clerids numerous, copulating.
June 8 Ips oregoni. Very light on first 8 ft.; moderate second 8 ft. Very heavy above to top diameter of 4"; lighter above and on large branches.
Pityogenes & Pityophthorus on limbs and twigs.
Clerids numerous, many copulating.
June 22 D. valens. 10 attacks on stump. 5 with pitch tubes.
Ips integer & oregoni. Moderate first 8 ft.; heavier second 8 ft. Heavy above.
Pityophthorus & Pityogenes. Heavy attack on limbs and twigs.
June 25 Acanthocinus sp. & Rhagium lineatum in copulation on bark of trunk.
June 29 D. valens. 13 attacks on stump, some heavy pitch tubes.
Ips sp. Moderately heavy on butt log. Heavy above.
Gnathotrichus. A few on butt log; many above up to 51 ft.
July 6 D. approximatus and D. valens on under side of first log.
Attack perhaps 2 weeks old.
H. subcostulatus. Very numerous. Interfering with D. approximatus.
D. ponderosae. A few only.
July 29 Ips oregoni. Young adults matured - some emerged.
Some pupae and large larvae.
Aug. 11 Ips oregoni. Nearly all emerged second log. Not quite so far matured on first log.
H. subcostulatus on under sides; larvae nearly full grown.

Tree B-c-3, 5/1/25 - 17" D.B.H. West of camp.

May 17 Ips sp. A few attacks (probably May 14).
May 18 " " Second log and up.
May 26 " " First log. A few attacks.
June 8 Ips oregoni & integer. Light on first 8 ft., few on second 8 ft. Moderately heavy on rest of trunk and limbs.
Pityogenes & Pityophthorus on limbs and twigs.
D. valens on stump.
June 15 D. valens. Heavy on stump. 6 attacks.
June 22 Ips spp. Average on butt log, moderately heavy above.
Pityophthorus & Pityogenes. Moderate on twigs.
June 29 D. valens. Much pitch still flowing.
Gnathotrichus. Very little on butt log, light above, none above 48 ft.

July 6 D. valens & H. subcostulatus. Numerous on underside butt log in first 8 ft.
D. approximatus. Several burrows second 8 ft.
Gnathotrichus. Heavier on second log, some up to 52 ft.

July 16 Ips oregoni. Second log nearly all young adults - little emergence. Sample sq. ft. gave 35 young. 3-5 Clerid larvae per ft.
D. approximatus. Mostly eggs. A few larvae in burrows 4 mm. long.

July 28 Ips oregoni, integer. Second log very few larvae.
D. approximatus & D. ponderosae. Butt log also H. subcostulatus

Aug. 3 Ips spp. Second log nearly all emerged.
Gnathotrichus retusus. To base of butt log.
Many Cerambycid larvae about 1/4" long.
Ips integer. Butt log, many young not yet emerged.
Hylurgops subcostulatus. Butt log, hundreds on under side.

Aug. 10 Cerambycid larvae - 1/4" to 1/2" long.
Buprestid larvae - a few.
D. approximatus
D. ponderosae
D. valens. Larvae in stump less than half grown.

Aug. 17 Ips oregoni. A very few adults still in second log.
Ips integer. Some still in butt log.
Clerid larvae. A few still present.

Aug. 25 D. approximatus, Gnathotrichus retusus, H. subcostulatus, Ips oregoni & I. integer. Still in butt log.

Tree B-c-4, 5/1/25 - 15" D.B.H. West ridge, near camp.

May 18 Ips sp. First and second log and above.

June 8 Ips spp. Attack light on trunk, heavy in top.

June 15 D. valens. Several in stump.

June 22 D. valens. 4 attacks.
Ips sp. Light attack on butt log, rather heavy above.

June 29 D. valens. 5 attacks.
Ips oregoni. Considerable on second 8 ft, heavy above 32 ft.
Gnathotrichus. Attacks begin on second log continuous to 54 ft. up.

July 6 Graphisurus obliquus. 5 specimens on first log; ♂ & ♀ copulating.
D. valens. Attacking under side of butt log.

July 15 Gnathotrichus retusus. Attack extends to base of butt log.

July 28 Ips integer. Not heavy on butt log, no emergence.
D. approximatus. On butt log.
H. subcostulatus. Many on under side of log.

Aug. 3 Ips integer. In pupal and prepupal stages on butt log.
" " Considerable emergence, others ready to emerge.

Aug. 17 Ips integer. A very few still in butt log, heavy emergence.

Aug. 25 Ips integer. 2 specimens remaining in 1 1/2 sq. ft.

Tree B-c-1, 5/29/25 - 15" D.B.H. East ridge, 1/2 mi. N.E. of camp.

June 8 No insect attacks. The preceding week had been very cold with 3 days of snow.
June 15 No insect attacks on trunk or branches.
June 22 D. valens. 1 pitch tube on stump.
Ips spp. A few near top of first log, more on second, fairly heavy above.
Pityophthorus & Pityogenes. Considerable on twigs.
June 29 D. valens. 9 attacks on stump
Ips spp. Light on first 8 ft., average above.
Gnathotrichus. No signs of attack.
July 6 D. ponderosae. 4 attacks on butt log. One with eggs.
Hylurgops subcostulatus. Considerable on under side.
Gnathotrichus retusus. A few above butt log.
Ips integer. On butt log.
July 15 D. approximatus. On east side.
Ips oregoni. Nearly full grown larvae, no prepupae, pupae or young adults.
Gnathotrichus retusus. A few on butt log, many above.
July 29 D. ponderosae. On butt log.
Ips integer. On butt log.
H. subcostulatus. On butt log.
Gnathotrichus retusus on butt log, a few on stump.
Aug. 17 Bark of butt log completely riddled by D. spp., Ips spp. and Hylurgops sp., Hylurgops extending to upper side of log.

Tree B-c-2, 5/29/25 - 19"D.B.H. Near last preceding.

June 8 No insect attacks.
June 15 Ips oregoni. A few above 32 ft. None on butt log.
Pityophthorus sp. A few on twigs.
June 22 D. valens. 7 attacks on stump.
Ips oregoni. Few on second log, numerous above.
Pityophthorus. Numerous on twigs.
June 29 D. valens. 9 attacks on stump.
Ips sp. Heavy above butt log, scattering on butt log.
Gnathotrichus. None.
July 6 Ips spp. Eggs mostly laid, some larvae with burrows less than 1/2 inch.
Gnathotrichus. None
Adults of Monochamus sp. Tetropium sp. on bark.
July 15 D. approximatus. One east side of butt log.
Ips oregoni. Larvae scarcely half grown.
Gnathotrichus. None on butt log, many above.
July 29 Gnathotrichus. On first log nearly to butt, a few on stump, very few on west side of log.

Aug. 3 Ips integer. On butt log, nearly full grown larvae.
Gnathotrichus. Extend to butt and on stump.
Aug. 11 Ips oregoni. On second log. No young adults, mostly pupae, prepupae and large larvae.
Ips integer. Butt log old adults, pupae, prepupae and full grown larvae, no young adults.
D. approximatus. Numerous in butt log.
H. subcostulatus. Very numerous in butt log.
Clerid larvae. Many, especially among Hylurgone.
Cerambycid larvae. Nearly 1/2 inch long.
Aug. 17 Ips integer. No young adults yet.

Tree B-c-3, 5/30/25 - 14" D.B.H. West of draw, 1 mi. north of camp.

June 8 No insect attacks.
June 15 Ips integer. 2 attacks on butt log, none above.
Pityophthorus sp. Considerable on twigs and small limbs.
June 22 D. valens. 5 attacks on stump.
Ips spp. Light on butt log, rather heavy up among branches.
Pityophthorus. Rather heavy.
June 29 D. valens. 11 attacks on stump.
Ips integer. Light on first 8 ft., rather heavy second 8 ft.
Ips oregoni. Heavy above butt log and on branches.
Gnathotrichus. None
July 6 D. valens. On butt log, under side.
D. approximatus. 2 attacks, under side of butt log, just started.
Gnathotrichus. 1 attack, second log, at base of twig.
July 15 Ips spp. Attacks heavier on second log.
Gnathotrichus. More on second log.
July 28 Gnathotrichus. Ambrosia attacks to butt.
Aug. 4 Gnathotrichus. Some on stump.
Aug. 10 Butt log yielded - I. integer, I. oregoni, H. subcostulatus, D. approximatus, Gnathotrichus retusus.
Aug. 21 D. valens burrows on stump examined, nothing but adults. Also yielded D. approximatus, H. subcostulatus, and Gnathotrichus sulcatus.

Tree B-c-4, 5/30/25 - 20" D.B.H. Near last tree.
Stump shows scars of old attack - 35, 49, 73 and 77 years back.

June 8 No insect attack.
June 15 Ips oregoni. A few attacks up among limbs.
Pityophthorus sp. On twigs, not heavy.

June 22 D. valens. 15 attacks on stump.
Ips oregoni. Light among limbs, none below.
Ips integer. 1 attack at juncture of first and second logs.
Pityophthorus sp. On twigs, not heavy.

June 29 D. valens. 28 attacks on stump
Ips spp. Heavy above second log, light on second log, none below.
Gnathotrichus sp. None

July 6 Ips spp. Moderate in second log, heavy above, some on butt log.
Gnathotrichus sp. None.

July 15 D. ponderosae. 1 attack on butt log, north side.
I. integer. New burrows, no eggs laid yet.
I. oregoni. Heavy larvae 1/2 grown.
Gnathotrichus sp. Some on second log.

July 29 Ips spp. Attacks light on second 8 ft., hardly any on first 8 ft.
Gnathotrichus. Some on butt log.
H. subcostulatus. On butt log.

Aug. 3 Gnathotrichus sp. Some to butt, not numerous on butt log.

Aug. 10 D. approximatus. North side well occupied by this.
Hylurgops, I. integer & oregoni and Gnathotrichus retusus.
Cerambycid larvae numerous 1/8" to 1/2" long.

Tree B-c-1, 6/29/25 - 19" D. B. H. West of camp, southern slope.

July 6 No insect attacks.

July 15 D. valens. 8 attacks on stump, 4 on butt log.
D. ponderosae. 12 attacks on butt log, none seen above.
Ips spp. A few above butt log and in tops, none on butt log.

July 28 D. valens. 10 attacks on stump.
D. ponderosae. Numerous attacks, especially on butt log.
Only 1 beetle in each burrow opened, no eggs.
Ips oregoni and integer. Heavy attacks above butt log.
Pityophthorus. Light attacks on twigs and small limbs.
Clerid adults still fairly numerous.

Aug. 3 D. ponderosae. Adults heard working in burrows - "ticking"
Ips spp. Many of both species above butt log, little or none on butt log.
Pityophthorus & Pityogenes. On limbs, not heavy.

Aug. 10 D. ponderosae. Several burrows opened, all with a single specimen, no eggs.
D. approximatus. On south side and on second log.
Ips spp. Both species on second log, heavy higher up.
Samples from this trap tree at this date showed
I. oregoni, I. integer, H. subcostulatus, G. retusus,
Pityophthorus sp., D. ponderosae and D. approximatus.

Aug. 25 D. convexifrons. Taken in addition to above.

Sept. 1 Much of foliage still green, part yellowed.

Tree B-c-2, 6/29/25 - 18" D.B.H. Near last tree.

July 6 No insect attack
July 15 D. valens. 7 attacks on stump.
D. ponderosae. Attacks on first and second logs.
Ips oregoni. A few attacks on second log and above.
Ips integer. A few attacks on second log and above.
July 28 Ips sp. Some on butt log, heavy above.
Pityogenes & Pityophthorus. On twigs and limbs.
Gnathotrichus sp. None
July 29 Adjacent trees attacked by D. ponderosae, 3 untreated, 1 hack girdled, 1 belt girdled. 5 in all.
Aug. 3 D. ponderosae & D. valens in stump.
Ips oregoni. Numerous in butt log, eggs laid and a few hatched. More numerous above butt log.
Aug. 10 D. approximatus in butt log with D. ponderosae, etc.
Ips oregoni. Numerous on second log and upper part of first log.
Pityophthorus sp.2 A few in butt log.
Gnathotrichus retusus. A few
Pityophthorus sp. 1. A few on twigs.
5 standing trees and 2 trap trees attacked by D. ponderosae.
Aug. 17 19 standing trees and 2 trap trees attacked.
Aug. 25 32 standing trees and 2 trap trees attacked.
This trap tree was apparently responsible for the location of this heavy (for this year) center of attack.

Tree B-c-3, 6/29/25 - 19" D.B.H. East ridge, just south of pasture.

July 6 No attacks - 1 dead D. ponderosae in bark crevice.
July 15 D. valens. 3 attacks on stump.
D. ponderosae. 8 attacks on butt log.
Ips oregoni. Several attacks second log.
July 28 D. valens. 4 attacks on stump.
D. ponderosae. More attacks, principally on butt log.
Ips oregoni. Moderately heavy above butt log.
Pityogenes & Pityophthorus. Considerable work on limbs.
Clerid adults numerous.
Aug. 3 D. valens. 6 on stump.
D. ponderosae. Numerous burrows on butt log.
Many Clerids - 1 Graphisurus obliquus on bark.
Aug. 10 D. approximatus. On butt log.
Ips spp. Numerous above first log.
Pityogenes & Pityophthorus. Heavy attacks on some limbs.
Aug. 17 Ips oregoni. Filling in on butt log.
H. subcostulatus - on under side.
Pityophthorus sp. 2. On first and second logs.

Tree B-c-4, 6/29/25 - 18" D.B.H. East Ridge near last tree.

July 6 No attacks
July 15 D. valens. 3 attacks on stump.
D. ponderosae. 9 attacks on butt log.
D. approximatus. On butt log north side especially.
Ips spp. On second log and above.
July 28 D. valens. 12 attacks on stump.
D. ponderosae. More on butt log.
Ips spp. Rather heavy above butt log.
Aug. 3 Ips oregoni. Very heavy above first log, larval burrows 1/2"+
D. valens. 18 attacks on stump, some are ponderosae.
Aug. 17 D. approximatus, D. ponderosae, D. convexifrons all on butt log.
H. subcostulatus. Very numerous under side.

Tree B-c-1, 7/29/25 - 12" D.B.H. East ridge, south of pasture.

Aug. 1 D. ponderosae. 2 attacks on butt log. No pitch tubes
2 attacks above butt log.
Aug. 3 D. ponderosae. 20 attacks first and second logs;
8 on south side, 12 on north side.
Ips spp. None.
Pityophthorus. A few on axial twigs.
Aug. 7 D. ponderosae. 95 attacks on butt log
60 attacks above butt log.
Aug. 10 D. ponderosae. Very heavy on butt log, lighter above.
Ips spp. None.
Pityogenes carinulatus. Some on limbs 4" - 5" dia.
Pityophthorus sp. 1. Some on twigs.
Aug. 14 (Small 8" tree, 3 ft. away heavily attacked. Some pitch)
(tubes white, some red.)
Aug. 17 D. ponderosae. Several burrows opened - about 3" long, some eggs laid.
Ips spp. None below branches, some 40 ft. up and above.
Aug. 20 (Small tree, 8" D.B.H., with tubes extending up 18 ft.)
(Some sawdust at base.)
(Another tree, 14" D.B.H., with numerous pitch tubes)
(Some white, some red.)
Aug. 25 (Small 8" tree filled in. Red sawdust at base)
(Larger 14" tree filled in. Red sawdust at base)
(Tree 15" D.B.H. 13 ft. S.E. heavily attacked)
(Small tree 21 ft. east lightly attacked)

Tree B-c-2, 7/29/25 - 19" D.B.H. East ridge, near preceding.

This tree was treated slightly different. It was felled, a 16 ft. log cut out, the top partly trimmed and the butt log lightly covered with branches.

Aug. 1 D. ponderosae. 1 attack above butt log.
Aug. 3 D. ponderosae. 4 attacks on butt log, 14 above.
Aug. 10 D. ponderosae.- 31 attacks on butt log. Considerable above.
Pityogenes & Pityophthorus on thin bark, limbs and twigs
More on trimmed branches.
Ips oregoni. Above butt log.
Aug. 17 D. ponderosae. Very numerous on butt log. Also considerable above.
Ips spp. Begin 20 ft. from stump.
Aug. 25 D. ponderosae. Butt log heavily attacked. Not so heavy above.

Tree B-c-3, 7/29/25 - 17" D.B.H. West of draw, N.W. of camp. South exposure.

July 31 D. ponderosae. 2 attacks on butt log.
Aug. 1 D. ponderosae. 9 attacks on butt log; 2 above.
Aug. 3 D. ponderosae. 28 attacks on butt log; 7 above.
D. valens. 2 on stump.
Aug. 10 D. ponderosae. 76 on butt log; 37 above. No pitch tubes.
Ips spp. Some above butt log.
Pityophthorus sp. 1. A few on twigs.
Aug. 17 D. ponderosae. Very many on butt log; considerable above.
Ips spp. 45 ft. up and above.
Aug. 25 D. ponderosae. 2 white pitch tubes on stump.
Ips spp. Extend down to butt log and a few on butt log.

Tree B-c-4, 7/29/25 - West ridge, near above South slope.

The butt log of this tree was covered as with B-c-2 of same date.

Aug. 1 D. ponderosae. 2 on stump, 3 on butt log.
Aug. 10 D. ponderosae. Very few on butt log, 10 above.
Aug. 17 D. ponderosae. Comparatively few on butt log.
Ips spp. A few above 35 ft. up.
Aug. 25 Ips spp. None below 30 ft.

Felled Road-Side Trees at Dry Park

These trees were not prepared as trap trees but were trees felled just west of Dry Park during the construction of the forest service road in late September and early October, 1925. The trees were felled, trimmed, cut into logs and drawn to the sides of the road. Some were left exposed to the sun, others lie in partial or full shade. These logs were found on June 11 and several were examined at that date. The following insects were obtained - D. ponderosae (a single specimen), D. convexifrons (25 specimens), Ips oregoni, Hylurgops subcostulatus, Hylastes sp. and Gnathotrichus retusus. Apparently all or most of these insects had attacked the logs since winter. The eggs of D. convexifrons were laid and a few had hatched and had burrows an inch long.

On July 26 a further and more detailed examination of these trees was made. In the same logs examined June 11 the D. convexifrons were now full grown larvae and pupae. The larval burrows extended for 1 to 1 1/2 inches at right angles to the parent gallery in the phloem but then turned outward and pupation occurred in the inner part of the outer bark.

From north side of another log were obtained Ips oregoni, H. subcostulatus, and a single specimen of D. ponderosae. From the north side of another log D. approximatus, D. valens, D. ponderosae, Ips oregoni and H. subcostulatus were obtained. Still another log yielded specimens of D. barberi, D. convexifrons, D. approximatus, I. oregoni, Orthotomicus ornatus and H. subcostulatus.

Still another log was found on the south side of the road in a dense growth of young pines where it was in complete shade - i.e. where the sunlight never reached the log. The entire absence of sunlight had retarded the entrance of insects into this log and the bark was only partially occupied by borers. Also the bark was surprisingly fresh although the tree had been cut about ten months previously. The sides and under side of this log yielded specimens of D. approximatus, D. convexifrons, Ips integer and H. subcostulatus. The upper surface of the log showed numerous recent attacks of D. nonidentatus. These varied from burrows just entering the phloem to others 9 or 10 inches long. A number of burrows contained eggs but none of these had yet hatched.

Summary of Observations on Felled Trap-Trees.

An attempt will be made to summarize very briefly some of the observations on attacking insects.

Ips oregoni and Ips integer. These two species will be considered together although the observations show many minor differences. Ips oregoni is much more numerous than the larger species and apparently is in flight in considerable numbers during all of the summer from early in May till September. It prefers to attack the upper portions of the trunk and larger branches but also is frequently found in the thicker barked lower trunk. The first spring attack on the trap trees was recorded May 17 and had occurred a few days earlier, probably about May 14.

The first recorded attacks in the trap trees under observation varied from 12 to 24 days after the tree was felled with an average of 17 days between felling and first attack. Except for one instance, first attack by Ips always occurred above the first log and usually near the first branches. The beetles usually fill in rather closely on the upper portion of the tree before the first log is attacked. By the time this part is filled in the butt log is often dried out to such an extent as to be attractive to them. The first attacks on the butt log usually occur one or two weeks later than the first attacks on the upper part but may not occur till considerably later.

Dendroctonus valens. This insect is in flight throughout most of the summer. One specimen was taken in flight May 28, the first day in the field. The first new attack was noted June 8 and the last new attack August 3. The height of the flight is apparently in the last two weeks of June. The elapsed time between preparation of the trap trees and first attack by D. valens varied from 5 to 24 days - the average being 17 days. However, three of the trap trees - all of them prepared July 29 - did not suffer any attacks, doubtless due to the scarcity of D. valens during August. The reaction of the tree to the attacks varies greatly. Some attacks produce very pitchy tubes from which the pitch may continue to flow for several weeks. On the other hand other attacks result in no pitch tube or flow of pitch whatever. In fact the same stump may show several pitch tubes, while only a few inches away may

be other attacks from which only "sawdust" is given off. A large number of attacks never result in the production of brood, but the adults after fighting the flow of pitch for a week or several weeks finally leave their burrow or are gummed up in the pitch without having laid any eggs. An examination of these trap trees early next summer should be made to determine the approximate percentage of successful attacks.

Dendroctonus approximatus. The first attacks by this species were observed on the bases of standing trees killed by D. ponderosae the preceding August on June 10. The first eggs were seen June 26 and the first larvae June 30. On the trap trees this species was first found July 6, but some of these attacks had occurred a week or more previously. The height of attack seems to occur during the last week in June and the first two weeks in July. Attacks continue up until the first week in August - possibly later. On standing trees the favorite breeding place is on the lower portion of the trunk of trees where the D. ponderosae have not filled in closely, and there is unmistakable evidence of a decided preference for the north side of the trunk. In felled trees the portion favored in attack is the bark on the half of the trunk nearest the ground.

Judging from the observations made both on standing trees and trap trees D. approximatus is decidedly a secondary insect and is less aggressive in its attacks than the two species of Ips in the same logs. This is shown by the fact that its attacks on the host occur considerably later

upon the same host than do attacks of Ips spp. This is well shown by the data for the trap trees of July 29, 1925. All of these were attacked by Ips within the month following their preparation, but none showed attacks by D. approximatus even though this species was during this time attacking older trap trees.

Dendroctonus convexifrons. This species was found attacking only two of the trap trees at Mile and a Half. The reason for this is perhaps that the flight of the insect did not coincide with the period during which the observations were made. D. convexifrons attacks in the late summer or fall and in the early spring. The earliest attack recorded of the 1925 generation was August 17, and another occurred on August 25. However, the roadside logs at Dry Park when examined June 12 showed numerous attacks, some of which may have occurred in the fall of 1924 but the most of which must have come in 1925 during May and early June. A later examination July 26, 1925, showed D. convexifrons in the late larval and pupal stages. Some of these would surely emerge and attack in August and September (as shown also by the attacks at Mile and a Half) but probably the majority would not emerge until the following May. This species normally fills in on the butts of trees killed by D. ponderosae. It is more aggressive than D. approximatus as it attacks the same trees several months earlier and occasionally attacks and kills weakened trees. Also in the case of trees which have been attacked by D. ponderosae in numbers insufficient to

kill them it often fills in on the bark and the two species together succeed in killing the tree. It is possible that under certain conditions this species may be capable of doing considerable damage, although it could never be as aggressive as several other species of the same genus.

Dendroctonus barberi. This species was not found attacking any of the trap trees at Mile and a Half. It was, however, found in several of the felled trees along the roadside near Dry Park. The date at which these logs were attacked is not known but from the condition of the bark at the time they were found (July 26) it seems probable the logs were not attacked until late in June. It is said that there are either one and a half or two generations of this insect each year (Hopkins) but no reliable data was obtained by me this year as the species was not found at all near our camp. It was obtained from standing trees on Greenland Plateau and at Fraser Lake.

Pityogenes carinulatus. Attacks by this species were for the most part confined to the smaller branches less than 2 1/2 inches in diameter but during the height of their second flight for the season in the second week of August numerous burrows were started in branches and tops up to 5 inches in diameter. There are two distinct periods of heavy attack during the summer. The first occurs in the middle and latter part of June and the second during the middle weeks of August. At these times the beetles can be seen and captured on the wing in considerable numbers.

They are especially numerous during cloudy, warm days and in the evenings from late afternoon until dark. During their flight in late August numerous small birds - principally warblers of a species unknown to me - were repeatedly seen upon the limbs of the trap trees and darting out and capturing these small barkbeetles and also Pityophthorus sp. 1 as they approached to attack the trap trees.

The promptness with which trap trees are attacked by P. carinulatus depends upon whether the insects are in flight in considerable numbers or not. The trap trees put down July 29 were heavily attacked within two weeks while those felled a month earlier had no recorded attack till four weeks had elapsed and were never heavily infested.

What effect do the burrows of Pityogenes and Pityophthorus occurring in the twigs and smaller limbs have upon the drying out of the wood? Does it hasten this process or does it slow it up? The burrows destroy the phloem and the superficial portion of the sapwood. The foliage on twigs heavily infested fades and turns brown sooner than that on non-infested twigs. This is doubtless because a large portion of the water supply to the leaves is cut off. But does the wood retain more of its moisture and dry out more slowly than it would otherwise? Is the lessened loss of water through the leaves compensated for by the greater loss of water through the insect's burrows? Is the quicker fading of the foliage due to a lessened supply of water on account of the disturbance of the water-carrying tissues or is there a lessened supply to the leaves because more of the water evaporates through the open burrows before it can reach the leaves? These are questions which can perhaps be best answered by a plant physiologist.

Pityophthorus sp. 1. This very small barkbeetle - apparently an undescribed species of Pityophthorus - seems to synchronize very closely in life history with Pityogenes carinulatus. It attacks principally the smallest twigs often making its burrows in the leaf-bearing portion of the twig and often also in the smaller limbs up to a diameter of nearly an inch. It thus occurs usually in the smallest twigs where Pityogenes seldom is found, but overlaps with this species in the smaller limbs. It attacks at about the same time as P. carinulatus and occurs on the same trees.

Pityophthorus sp. 2. This undescribed species was found only in the trunk of yellow pine. It was in flight in early August and on August 10 numerous attacks were found in the felled trap trees of June 29. Its burrows occur both on the butt log and on the upper portion of the trunk and are closely associated with the burrows of Ips oregoni and I. integer.

Gnathotrichus retusus. Some interesting data was obtained for this ambrosia beetle and it is regretted that more detailed notes were not taken. The attacks of this species seem to act as a very good indicator of the condition of the log as regards the extent to which it has dried out. They seem to be in flight continuously during the period from the last week in June until the middle of August. The felled trap trees are attacked in the region above the first sawed out log usually at about thirty feet from the stump. From this the attacks proceed both upward and downward filling in the upper portion of the tree. The butt log is

not attacked until from one to three weeks after the top. The attack on the butt log begins at the upper end and gradually fills in down to the base. Last of all the stump is attacked and filled in.

The first attacks upon the trap trees varied considerably according to the date on which these were prepared. Those laid down April 30 were attacked during the week preceding June 29 after about 60 days. Those prepared May 29 and 30 were attacked 37 to 44 days later. It is probable that this ambrosia beetle was not in flight in any numbers until after the middle of June.

Gnathotrichus sulcatus. Only a few specimens of this species, closely allied to the foregoing, were taken and these were obtained August 21 from the stump of one of the trap trees of May 30. The approximate date of attack is not known. Also it is not known whether or not this species is confined entirely to stumps and the lower parts of standing trees or not. However, of the many ambrosia beetles obtained from the logs, none were of this species. In the field it was not recognized as distinct from G. retusus which it very closely resembles.

Hylurgops subcostulatus. This species seems to choose a very sappy portion of the bark for its breeding place. But as it usually defers its attack for some time after the tree is felled or killed it probably also requires a "cooked" condition of the sap as well. It is in flight from May till September. In standing trees it is invariably found breeding in the green butts of trees attacked and killed

the preceding late summer. Here it is associated with Ips integer, Ips oregoni, D. convexifrons, D. approximatus, D. ponderosae and Orthotomicus ornatus.

In trap trees H. subcostulatus is found breeding principally in the under side of the log, especially in the butt log. They usually do not attack the trap trees until five weeks or more after these are felled. Usually their attacks are preceded by those of D. approximatus, D. convexifrons or D. valens in the same regions. They are especially closely associated with D. approximatus in the trap trees and many Hylurgops appear to utilize the entrance galleries of the larger bark beetle in gaining entrance to the inner bark. H. subcostulatus is very numerous and probably passes through two generations each summer, and they appear to be numerous at all times of the season.

Orthotomicus ornatus. This species is fairly common during early summer in the trunks of standing trees killed by D. ponderosae. It was not found attacking any of the trap trees at Mile and a Half but was found in one of the felled road side trees at Dry Park where it was associated with D. Barberi, D. approximatus, D. convexifrons, I. oregoni and H. subcostulatus.

Dendroctonus ponderosae. The first attacks upon the trap trees by D. ponderosae were recorded on July 6. On that date two felled trap trees were attacked - one treated 6/30/25 and the other 5/29/25. These were probably adults which had been disturbed by the felling of numerous

infested trees near by. However, on June 11 a single specimen of this species was obtained from one of the felled trees along the road near Dry Park.- this either being a spring attack by a specimen which had wintered over in the old host or a spring attack by an overwintered female which had laid most of its eggs in some other tree the preceding year. On July 15 five more of the logs had suffered first attacks, the beetle showing a decided preference for the more recently felled trap trees of June 29.

The trap trees put down July 29 were attacked very promptly as at that time the beetles were just beginning to emerge in considerable numbers. Thus B-c-1 of that date showed two attacks on August 1, 20 by August 3 and 155 on August 7-only 9 days after the tree was felled. The others were attacked equally promptly but did not fill in quite so rapidly. From the middle of July up until August 26 all felled trap trees were promptly attacked. Those most recently prepared were attacked more promptly and seemed to offer a greater attraction. One reason for this doubtless was that the older trap trees, i.e. those prepared before June 29, were pretty well filled in with other species by the time the flight of D. ponderosae had begun.

Three centers of infestation were started by felled trap trees. One of these consisted of only two standing trees, including one hack girdled tree near B-c-1 of 5/29/25. A second infestation was centered around B-c-2 of 6/29/25 and involved one hack girdled tree, one belt

girdled tree and thirty two untreated trees. Not all of these were killed and the flight of the beetles had practically ceased by August 25. The third infestation centered in trap tree B-c-1 of 7/29/25 and involved four trees, three of which suffered very heavy attack. Thus centers of infestation were started by three different felled trap trees put down at intervals of a month - May 29, June 29 and July 29, 1925.

The question as to the effect of the trap trees upon the survival of the brood cannot be answered until a thorough examination of the trap trees is made next summer. In this connection also it will be interesting to note if there are any striking differences in the survival in the trap trees covered with brush on July 29 as compared with those of the same date not covered. There was a difference in attack as regards promptness of attack and filling in but from casual observation it is believed that there is no striking differences with regard to the ultimate number of attacks.

The large center of infestation surrounding trap tree B-c-2 of 6/29/25 if studied more in detail may offer some points of interest. The felled trap tree showed several attacks by D. ponderosae as early as July 15. Between that date and July 26 it became well filled in with the beetles' Burrows. On July 29 one hack-girdled tree (B-b-2 of 6/29/25), one belt-girdled tree (B-a-2 of 6/29/25) and three standing untreated trees showed light attacks. The data for the trap trees has already been given and that for the untreated trees will be found in

the following pages and their relative position shown on the accompanying rough map. These trees were spotted as soon as they were observed to be attacked and each was marked with a letter corresponding with those on the map.

Tree-A. 8 1/2" D.B.H. Spotted July 29 with 7 white pitch tubes showing. August 1 - 11 attacks; August 7 - 25 attacks; August 10 - 34 attacks; August 14 - 51 attacks; August 19 - filled in and sure to die.

Tree-B. 10" D.B.H. Spotted July 29. Suppressed and cat faced on north side. In nearly dying condition as it had been previously attacked by D. convexifrons. August 10 filled in completely.

Tree-C. 14" D.B.H. Vigorous tree. Spotted July 29 with 11 attacks. August 1 - 16 attacks; August 3 - 24 attacks; August 4 - 36 attacks; August 7 - 100 attacks; August 10 - 129 attacks; August 14 - 170 attacks; August 17 - filled in.

Tree-D. 16" D.B.H. Sturdy tree. Spotted August 10 with 2 attacks showing. August 14 - 7 attacks; August 16- 17 attacks; August 19 - many attacks; tree filled in and killed.

Tree-E. 28" D.B.H. Very vigorous tree. Spotted August 11 with very numerous, very pitchy tubes 20 feet up. None below 8 ft. from base. Lower tubes not so pitchy. August 14 - 173 attacks; August 16 - much red sawdust at base of tree; August 19 - attacks extend to base of tree. Filled in. On August 24 this tree was felled, an 18 ft. log cut out and covered with brush in fall experimental treatment to foster brood (See C-6, 8/24/25).

Tree-F. 9" D.B.H. Suppressed, weak tree. Spotted August 10 with 30 pitch tubes - all red and with little pitch; August 14 - 68 pitch tubes; August 19 - filled in, much red sawdust.

Tree-G. 9" D.B.H. Partly suppressed, rather weak. Spotted August 13; August 16 - 18 pitch tubes; August 19 - numerous attacks up to 15 ft. Later tubes red and mostly boring dust. Filled in and killed.

Tree-H. 15" D.B.H. Spotted August 14 with 13 attacks. August 16 - heavy attacks, probably more than 100. Many tubes small and red. Red sawdust at base. Few attacks below 9 ft. August 17 - a few attacks below 6 ft. August 19 - much red sawdust at base, many new tubes down to 2 1/2 ft. from base. August 22 tree felled, 16 ft. log cut out, caged and covered with brush. Fall experimental treatment (See T-c-7, 8/22/25).

Tree-I. 13" D.B.H. Scaly bark. Spotted August 14 with one pitch tube showing. August 16 - 2 attacks; August 17 - 4 attacks; August 19 attacks numerous above 10 ft. Pitch tubes red. Some sawdust at base; August 24. Tree felled, one 18 ft. log cut out and covered with brush in fall experimental treatment (See C-7, 8/24/25).

Tree-J. 12" D.B.H. Spotted August 14 with one attack showing. August 16 - 3 attacks; August 17 - 7 attacks; August 19 - numerous attacks, later tubes red; August 22 - much red sawdust, tree doomed; August 24 - felled, one 18 ft. log cut out, caged and covered with brush (See T-c-8, 8/24/25).

Tree-K. 12" D.B.H. Spotted August 15 by one pitch tube. August 16 - 6 attacks; August 17 - 10 attacks; August 19 - 35 attacks visible; August 22 - filled in. August 24 - felled, one 22 ft. log cut out and covered with brush (See C-10, 8/24/25).

Tree-L. 15 1/2" D.B.H. Spotted August 16 with one pitch tube. (A beetle had been heard to alight on it the preceding day.) August 17 - numerous small red tubes, also considerable brown bark dust, showing other attacks which have not yet tapped the pitch. "Ticking" sounds of beetles at work can be heard a yard away. August 19 - attacks extend down to 3 ft. Considerable red sawdust. August 24 - felled, 24 ft. leg cut out and covered with brush (See C-6, 8/24/25).

Tree-M. 14" D.B.H. Spotted August 16 with one pitch tube. August 17 - 3 attacks; August 19 - still only a few tubes present and these very pitchy and white. This tree was not filled in by September 1.

Tree-N. 15" D.B.H. Spotted August 16 with 9 attacks showing. August 17 - 30 attacks; August 19 - many new attacks, with red sawdust tubes. Some red sawdust at base of tree. August 20 - filled in. August 24 - felled, 24 ft. log cut out, caged and covered with brush (See T-c-9, 8/24/25).

Tree-O. Spotted August 16 with 2 pitch tubes showing. August 19 - attacks fairly numerous about 30 ft. up, a few down to 9 ft; August 22 fully infested, red sawdust at base plentiful. August 24 - felled, infested length cut out and laid flat on ground (See S-4, 8/24/25).

Tree-P. 18" D.B.H. Spotted August 16 with one attack visible. August 19 - not many tubes. This tree not filled in by September 1.

Tree-Q. 4" D.B.H. Small scrubby suppressed tree. Spotted August 17 with 3 pitch tubes. August 19 - 5 attacks, perhaps enough to kill this small weak tree.

Tree-R. 6 1/2" D.B.H. Spotted August 17 with one red pitch tube showing. August 19 - 3 attacks visible.

Tree-S. 7 1/2" D.B.H. Spotted August 17 with one attack visible. August 19 - 4 attacks, all rather pitchy.

Tree-T. 12" D.B.H. Spotted August 19 with rather numerous small red pitch tubes showing about 10 ft. up.

Tree-U. 16" D.B.H. Spotted August 19 with red pitch tubes showing above 9 ft. August 20 - attacks extend down to 3 ft. August 24 - filled in. Considerable red sawdust at base. Sure to die. August 25 - felled, 24 ft. log cut out and covered with brush (See C-9, 8/24/25).

Tree-V. 13" D.B.H. Spotted August 19 with one red pitch tube. First spotted by ear and pitch tube seen later.

Tree-W. 16" D.B.H. Spotted August 19 with one attack visible.

Tree-X. 12" D.B.H. Spotted August 19 with one red pitch tube visible.

Tree-Y. 11" D.B.H. Spotted August 19 with several red pitch tubes visible.

Tree-Z. 16" D.B.H. Spotted August 20 with several white tubes visible.

From this data it is evident that the flight began late in July, reached its maximum between August 14 and 17 and declined rapidly thereafter. Only one tree in this group spotted later than August 16 was successfully attacked. This one (Tree-V) although spotted for the first time on August 19 had very likely been attacked several days previously and had escaped earlier detection.